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SUBALPINE WATER BALANCE SIMULATION MODEL DOCUMENTATION

by
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SUBALPINE WATER BALANCE SIMULATION MODEL

DOCUMENTATION

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Preface

This documentation is composed of several separate documents. At the present time, it includes a user's guide, an operator's guide, and a discussion of recently developed streamflow routing procedures. Each could be a "stand-alone" package suited for the indicated persons; they are combined here merely to facilitate production and distribution. Two other sections, Systems Analysis and Internal Logic, are omitted here. The Systems Analysis, or complete discussion of the theoretical aspects of the Subalpine Water Balance Model, has been published by Leaf and Brink [1972a,b; 1973a,b] in earlier papers. The internal logic section is contained within voluminous listings of the FORTRAN routines, which contain extensive comment statements, and within the inter-routine cross-referencing listing, which provides detailed analyses of the routines and their variables. Copies of the publications and/or listings may be obtained by contacting the authors.

Subalpine Water Balance Simulation Model

User's Guide

Preface

(User's Guide)

This user's guide defines the parameters which the user must supply to operate the Subalpine Water Balance Simulation Model. A general concept of each parameter's use is included, along with a range of values where appropriate.

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Effective Use of This Guide

Q. Who should use this guide?

A. It is intended for use by the hydrologist, research scientist, or land manager who has a working knowledge of subalpine hydrology and desires to know the probable effects of proposed management alternatives. Familiarity with computers or with the technical aspects of the model is not required.

Q. What does the guide contain?

A. The guide includes:

1. Discussions of the necessary items of information (referred to as "parameters") for running the model

2. Forms for recording the parameters.

3. A discussion of the capabilities and limitations of the model.

4. Examples of 1 and 2 for a sample watershed.

5. Sample output.

Q. When should this guide be used?

A. It is best utilized during the earliest stages of preparing to run the model and during the refining or calibration phase of the runs. Only occasional references will be needed when the production runs are made to test the alternatives.

Q. What preparation is required?

A. One suggestion is to obtain copies of the sample worksheets contained in appendixes A and B. They provide a format for the parameters, which is compatible with this guide and with the operator's guide. Location, topographic, and forest type maps are required. Long-term records of daily temperature extremes, daily precipitation, snowcourse observations and annual snowmelt hydrographs are necessary. Tables of potential solar radiation [Frank and Lee 1966] are required. Additional information on soil water holding capacity and forest cover composition and density is also helpful.

Q. What are the underlying purposes of this guide?

A. Two main purposes are: 1) to provide the prospective user with an overview of what is required if he is going to use the Model, and 2) to lead him through the necessary steps for productive simulations.

Q. How is this guide best used?

A. The user should scan the table of contents to be familiar with the topics and their order. The best initial approach is a methodical one in which each section and its worksheets are completed before proceeding to the next.

Introduction

I. Purpose

The model simulates the water balance within a subalpine watershed where virtually all of the runoff is derived from melting snow. The principal hydrologic components within several response units are simulated on a continuous year-round basis, and results from each unit are compiled into a "composite overview" of the entire drainage area. The model has been specifically designed to simulate watershed management practices and their resultant effects on hydrologic system behavior.

II. Method

The energy components available for snowmelt are short- and longwave radiation. Shortwave radiation to the snow or ground surface beneath the forest canopy is controlled by a transmissivity coefficient which varies according to forest cover characteristics. The incident shortwave radiation as measured on a horizontal surface is adjusted according to the slope and aspect of each hydrologic subunit.

Snowpack reflectivity varies with precipitation form, air temperature, and energy balance. During the winter months, unsteady heat flow theory is used to simulate temperatures within the snow cover. The snowpack will yield melt water only when it has become isothermal at 0° C., and its free water holding capacity is exceeded.

Potential evapotranspiration is computed by a modified version of the Hamon equation [Hamon 1961], which requires latitude, converted to day length, and mean monthly temperature, converted to saturation vapor density. The coefficient, C, in Hamon's equation was adjusted upward to obtain an expression for potential evapotranspiration under "unlimited" solar input, assumed here as potential radiation. The evapotranspiration computed by this expression is reduced in proportion to the radiation actually received each day. The adjusted evapotranspiration is then redefined according to its source, which can include: (1) evaporation from snow intercepted by the forest canopy, (2) evaporation from the snowpack surface, and (3) evapotranspiration during the growing season. If the source is evapotranspiration, further adjustments are made to account for: (1) available soil water in open or forested areas, using a method similar to that of Denmead and Shaw [1], and (2) the reflectivity of open or forested areas. If the source is evaporation from the snowpack surface or from intercepted snow, adjustments are also made to account for open areas and forest cover composition and density.

Input to the system is derived from snowmelt and rainfall. Once evapotranspiration requirements have been satisfied, additional input satisfies soil mantle recharge requirements. When field capacity is reached, the residual input becomes water available for streamflow (generated runoff).

III. Processing Performed

The user may choose to simulate only the natural conditions, or he may choose any of 3 watershed management alternatives:

1. Clearcutting in patches
2. Selective cutting (thinning)
3. Weather modification (cloud seeding).

Any combination of the three alternatives may also be selected.

The model provides four different forms of output, which allows the user to select varying levels of detail and to control the volume of output. In ascending order by volume of output, they are:

1. Yearly totals and average year for only the basic hydrologic components
2. Interval sums and year to date totals for only the basic components
3. Daily detailed output for all components (temperatures, radiation, etc., as well as the basic components)
4. Individual substation output in forms 1 and/or 2.

Graphical representations of the basic components are available with each option.

IV. Restrictions and Limitations

1. The water balance up to and including generated runoff (water available for streamflow) is simulated; no routing is performed by the present version of the model. Routing procedures are presently being developed, and will be incorporated into the model in the near future.

2. The clearcutting option allows patch-cutting of between 10 and 75 percent of a response unit. However, to simulate a complete clearcut, the thinning option may be used to reduce canopy cover density by 100 percent.

3. The time intervals for temperature extremes and total precipitation must be 1 day (i.e., daily temperature extremes and precipitation).

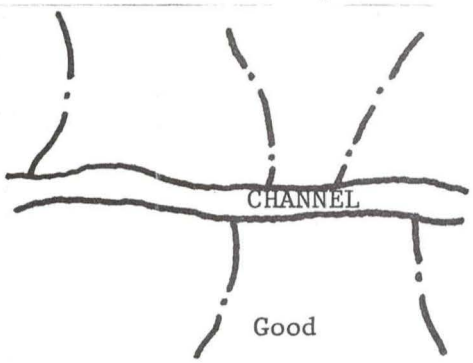
How to Use

I. Specifying the input data

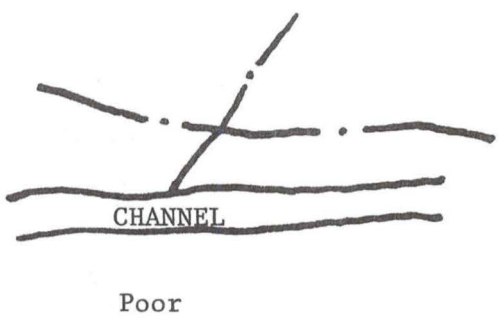
By utilizing the forms in appendix A, the user may follow the outline below to prepare the parameters in an orderly fashion and at the same time, prepare instruction sheets for the operator who will run the job.

A. Subdividing the basin: The following characteristics and procedures will help in selecting areas to be designated as response units:

1. Since the model is not designed to route excess water through the soil mantle, all response units should border on a stream channel, thus contributing runoff directly to the channel. Examples:



All subunits border on the channel.

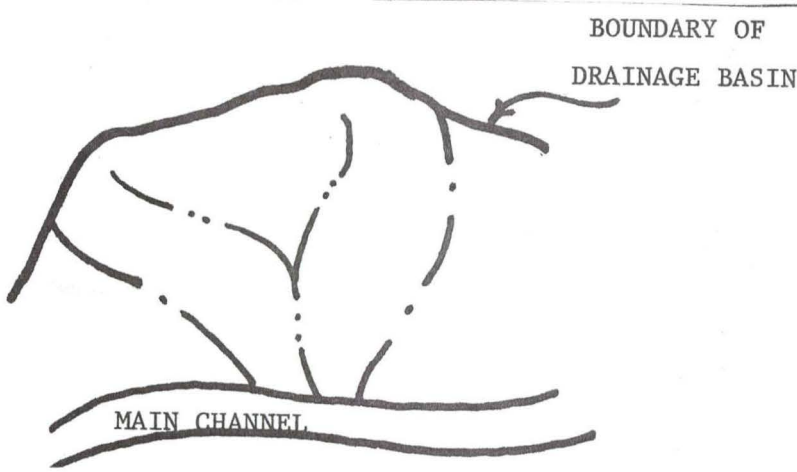


The areas in the upper portion would not contribute runoff directly to the channel.

2. A response unit should have a reasonably uniform slope and aspect.

3. If it is forested rather than naturally open, the forest cover composition and density should also be reasonably uniform.

4. If a response unit is consistent in the above requirements, but encompasses several sub-watersheds, it might be further subdivided by those sub-watersheds. Example:



A hydrologic unit which met all other qualifications is further subdivided by sub-watersheds.

5. It is helpful, but not mandatory, to number each in a pattern logical to the user.

6. As a rule-of-thumb, response units should average about 10 percent of the total watershed area.

B. Describing each response unit (Use forms A-2 and A-3 from appendix A.)

1. Name or Description - Use slope, aspect, elevation, unique topographic features, or other items which would quickly identify the response unit. The operator is limited to 50 characters--he may need to abbreviate. Examples:

LEXEN CREEK NORTH SLOPE, 9,800-10,500 ft.

LEXEN CREEK SOUTH SLOPE, NATURAL OPENING

LEXEN CREEK ALPINE, 5 PERCENT SLOPE, WEST FACING

2. Code - A shortened version of the name, this may contain the number of the response unit, aspect, etc. It is limited to 10 characters and is used frequently for identification. Examples: *1-H2 NORTH: 5SE, OPEN; 3W-ALPINE*

3. Area Weight - Express the response unit area as a decimal percent of the entire basin area. Examples: .015; .21; .08

4. Transmissivity Coefficient: (If left blank, the model will supply a value as a function of the forest canopy density.)

   Estimate the decimal percent of the solar radiation reaching the canopy which is transmitted (allowed to pass through) to the snowpack and/or understory. The following table summarizes combinations of cover densities and transmissivity coefficients which were found acceptable during the calibration of the model in lodgepole pine and spruce-fir forest in central Colorado:

COVER DENSITY	TRANSMISSIVITY COEFF
0.00 (open)	1.00
.25	.45
.30, .35	.40
.40	.35
.45	.30
.55, .65	.25

5. Cover Density: Using the above table as a guide, estimate the forest canopy density as a decimal percent. (In the table, the values below 50 were for lodgepole pine, with those above 50 for spruce-fir.)

6. Maximum Cover Density: Normally, this value is the same as number 5. But if a reduction in cover density is desired, this variable will allow adjustments to be made in the evapotranspiration and energy balance to compensate for that reduction.

7. Vegetation Type - Indicate the forest canopy composition as lodgepole pine, spruce-fir, or deciduous.

8. Reflectivity Threshold Temperature: The model assumes that fresh snowfall increases the snowpack reflectivity according to internally controlled functions. However, field experience has shown that it is not necessarily increased during snow events where the daily maximum temperature exceeds a base temperature. This base temperature varies according to aspect and elevation. The table below indicates some station characteristics and corresponding reflectivity threshold temperatures.

Station		Ref. Threshold Temp.
Relative Elevation	Aspect	°F.
High	North, East	32
Low-Middle	East	40
Low-Middle	North	45
All ranges	West	45
Low	South	60
Middle-High	South	70

9. Melt Threshold Temperature - During initial snowpack accumulation, the model relies on a base temperature to stop melt when the mean daily temperature is below that base. A knowledge of the typical pattern of fall snow accumulation will guide the user in selecting a threshold temperature. Areas where the snowpack accumulates and melts frequently might indicate a low threshold (32° F.). High thresholds (40°-45° F.) may be assumed where the snowpack may yield some melt, but generally continues to build once started.

10. Available Soil Water - Estimate the soil mantle recharge requirement at which water is no longer available for transpiration. Examples: -5.3; -7.8; -10.6 inches.

11. Deciduous Winter Values - The values defined in items 4, 5, and 6 represent the foliated conditions of a deciduous forest. Corresponding values must be supplied for the defoliated state and must represent the reduction in cover density between the seasons. The values used most frequently for cover density and maximum cover density on aspen stands in the central Rockies were .35 and .20 for the foliated and defoliated states, respectively. The model was allowed to generate the transmissivity coefficients as a function of those cover densities.

12. Initial Conditions - Define the following items for the conditions which exist when the first data card is read. The normal simulation must always be defined. If a watershed management alternative is being simulated, specify those conditions under "Area 1"; if patch-cutting is involved, the area cut must be treated separately within the model, so specify its initial conditions under "Area 2." The items to be defined are

a. Snowpack temperature, °C.
b. Snowpack water equivalent, inches
c. Recharge requirement, inches
d. Should the snowpack temperature be immediately under control of the diffusion model? (Normally, no = 0; otherwise, yes = 1)

Examples:

Temp.	W.E.	Recharge	Immediate control?
0.0	0.0	-3.5	0
0.0	2.5	-4.3	0
-3.0	7.0	-2.1	1

13. Average Daily Evapotranspiration - Obtain estimates of the average daily evapotranspiration in inches for each month.

The following table summarizes potential evapotranspiration rate for typical subalpine response units.

POTENTIAL DAILY EVAPOTRANSPIRATION BY MONTHS FOR TYPICAL SUBALPINE HYDROLOGIC RESPONSE UNITS

Response Unit	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Inches											
Low South Slope	.0463	.0558	.0893	.1481	.2314	.3098	.4007	.3308	.2123	.1254	.0665	.0427
Middle North Slope	.0192	.0296	.0529	.1001	.1860	.2671	.2702	.3517	.1481	.0698	.0280	.0154
Low North Slope	.0154	.0326	.0709	.1322	.2188	.3047	.3878	.3088	.1884	.0827	.0266	.0101
Low East Slope	.0401	.0499	.0762	.1226	.1913	.2576	.3245	.2650	.1711	.1021	.0548	.0361
High North Slope	.0167	.0242	.0451	.0812	.1524	.2204	.2791	.2094	.1188	.0581	.0266	.0140
High East Slope	.0427	.0529	.0827	.1336	.2054	.2724	.3503	.2920	.1897	.1126	.0601	.0386
High South Slope	.0427	.0529	.0827	.1336	.2054	.2724	.3503	.2920	.1897	.1126	.0601	.0386
Middle South Slope	.0401	.0499	.0762	.1308	.2054	.2778	.3603	.2986	.1909	.1112	.0574	.0376

14. Air Temperature Correlation Coefficients - Supply the correlation coefficients for predicting the daily extreme temperatures in °F. from a base station, where the coefficients A and B are of the form,

$$T_{subunit} = A + B(T_{base})$$

If the entire basin is being considered as a unit with observed extremes available, the coefficients would be 0.0 and 1.0, respectively. Examples:

Maximum A = 4.779	B = 0.907
Minimum A = 0.698	B = 1.023

15. a. Slope/Aspect Adjustments and Radiation - Using the tables by Frank and Lee [1966], compute the decimal percent of the potential radiation incident to a horizontal plane that effectively reaches a response unit of a given slope and aspect.

Example:

Using the columns entitled LY from the tables on the following page which were taken from Frank and Lee [1966], the slope/aspect adjustments would be:

June 22		0.998	(1020.7/1022.7)
May 18	Jul 27	.995	
May 3	Aug 10	.980	
Apr 19	Aug 25	.970	
Apr 4	Sept 9	.955	
Mar 21	Sept 23	.939	
Mar 7	Oct 8	.919	
Feb 20	Oct 22	.898	
Feb 7	Nov 5	.875	
Jan 23	Nov 19	.853	
Jan 10	Dec 3	.833	
Dec 22		.820	

Horizontal Surface

Latitude 40 N

		SR	SS	LY
June 22		-7.43	7.43	1022.7
June 1	Jul 12	-7.32	7.32	1004.2
May 18	Jul 27	-7.14	7.14	971.5
May 3	Aug 10	-6.90	6.90	923.5
Apr 19	Aug 25	-6.62	6.62	860.7
Apr 4	Sept 9	-6.32	6.32	786.3
Mar 21	Sept 23	-6.00	6.00	702.5
Mar 7	Oct 8	-5.68	5.68	615.6
Feb 20	Oct 22	-5.38	5.38	531.8
Feb 7	Nov 5	-5.10	5.10	456.5
Jan 23	Nov 19	-4.86	4.86	395.9
Jan 10	Dec 3	-4.68	4.68	353.5
Dec 22		-4.57	4.57	328.9
		Year	R.I.	
		253.658	0.4826	

Latitude 40 N
Aspect NE - NW

		10 PCT		
		Theta		Alpha
		43.9		5.6
		SR	SS	LY
June 22		-7.43	7.28	1020.7
June 1	Jul 12	-7.32	7.15	998.7
May 18	Jul 27	-7.14	6.94	960.4
May 3	Aug 10	-6.90	6.66	904.9
Apr 19	Aug 25	-6.62	6.34	833.7
Apr 4	Sept 9	-6.32	5.99	750.7
Mar 21	Sept 23	-6.00	5.63	659.1
Mar 7	Oct 8	-5.68	5.26	565.8
Feb 20	Oct 22	-5.38	4.91	477.3
Feb 7	Nov 5	-5.10	4.59	399.2
Jan 23	Nov 19	-4.86	4.31	337.2
Jan 10	Dec 3	-4.68	4.10	294.4
Dec 22		-4.57	3.98	269.8
		Year	R.I.	
		240.266	0.4571	

b. Because reliable radiation data are not consistently available, the shortwave radiation input to the model is generated from potential solar beam radiation as a function of the maximum temperature and the slope/aspect characteristics of a given station. The model interpolates linearly between the values to arrive at a potential for each day. That potential is then adjusted by the radiation factor which varies according to degree-days. Degree-days are computed by the following functions, which vary according to maximum temperature:

Months	Degree-Days =
Oct. thru Apr.	$.44(T_{MAX}) - 15.9$
May and Sept.	$.53(T_{MAX}) - 19.5$
June thru Aug.	$.63(T_{MAX}) - 24.1$

Once the degree-days have been established, the radiation factor is selected from the relationship in the table below, with one exception: During June, July, and August precipitation events, the radiation factor is assumed to be a constant 44 percent. All potential radiation values are adjusted by a radiation factor. The value thus obtained is the incoming radiation incident to a horizontal surface. It is adjusted once more to compensate for the slope and aspect of each station as discussed above.

Degree-Days	RADFACT
1	0.35
2	.45
3	.51
4	.56
5	.59
7	.64
9	.67
11	.69
13	.71
15	.72
20	.73
25	.75

16. Specified Conditions - Define the following observed conditions for each year to be processed:

    a. Peak snowpack water equivalent (inches).

    b. Accumulated precip up to, but not including, the date of the peak W.E. (inches). If left blank, the model will search the data file and complete the information; however, as it is somewhat time consuming, the user should punch the values from the table printed by the model into the cards for successive runs. This value is used to adjust the pre-peak precipitation events to ensure the buildup of the snowpack; it is designed to extrapolate base-station precipitation to observed or estimated snowpack water equivalent on the drainage basin as in the footnote discussed below.*

    c. The date of the peak water equivalent.

    d. The date by which the snowpack on all response units must be isothermal.

C. Describing the Watershed (Use form A-1 from appendix A)

    1. *Watershed Name and Description.* Within a 60 character limitation, the user may identify the watershed with items such as geographical location, elevation, etc.

    2. *Adjustment factor for base station precip <u>after</u> the peak snowpack accumulation has been achieved.* The user may increase or decrease the base station measurements by a fixed percentage for the remainder of the water year. The factor must be expressed as a decimal percent: 15 percent increase would be 1.15; 10 percent decrease would be 0.90. If no adjustment is warranted, it may be left blank and 1.00 will be assumed.

---

*To ensure proper accumulation of the snowpack as determined from field studies, the base station precipitation is adjusted by the model until the specified peak water equivalent at each station is reached. Each precipitation event prior to achieving the peak is adjusted by the following factor:

$$\frac{W.E._p - W.E._c}{PPT_p - PPT_{c-1}}, \text{ where}$$

$W.E._p$ = Peak Water Equivalent

$W.E._c$ = Current Water Equivalent as derived by the model

PPT_p = Total Precip from 10/1 to date of peak W.E. at the base station

PPT_{c-1} = Total Precip from 10/1 up to, but not including, this precip event at the base station.

3. *The number of subunits and the number of water years to be processed.* (Any fraction of a water year must be counted as a full year.)

4. *The potential radiation incident to a horizontal surface at the proper latitude as described in Frank and Lee* [*1966*].

SPECIFYING THE PROCESSING DESIRED

I. General.

The normal simulation, i.e., the simulation for the virgin watershed, is performed on every run. The user may choose one of three basic alternatives (watershed management options) or any combination of the three to be run simultaneously with the normal simulation. The normal simulation always prints on one line, with the alternative printing on the next line. Four main methods of output are available to give the user varying degrees of detail for comparing an alternative against its unaltered counterpart. Computer printed plots (graphs) also provide visual representations of the changes resulting from the alternative.

II. Methods of Output.

The number of pages generated and the central processor times for each of the methods below (including plots) are listed in tables 1 and 2, respectively. The user should provide the operator with the appropriate sheet(s) from Appendix B to specify the processing desired. Instructions for selecting and completing those sheets are as follows:

A. Select the form of output from the list below.

1. Interval Sums (Use sheet B-1) - Prints a composite line of all stations on the dates divisible by the user's specified time base. Examples: 10 would print lines on the 10th, 20th, and 30th of each month; 5 on the 5th, 10th, 15th, . . . 30th of each month; and finally, 1 on each day of the month. Each line contains 1) the date; 2) the snowpack water equivalent and recharge requirement on that date; 3) the accumulated amounts since the last date printed for precipitation, input (snowmelt and/or rainfall), evapotranspiration (with its sources), and snowmelt generated runoff; and 4) the year-to-date (water year) accumulation for each of those items. A sample output is on page D-1.

2. Daily Detailed Lists (Use sheet B-2) - Prints a composite line of all stations for each day with the following information: date; maximum, minimum, and mean air temperatures; precipitation for the day and water-year-to-date accumulation; water equivalent of intercepted snow remaining on the canopy at the end of the day; short- and longwave radiation balance; net energy balance; snowpack temperature and water equivalent; input (snowmelt and/or rainfall); evapotranspiration with its sources; recharge requirement; and the snowmelt generated runoff. The interception, radiation

balances, energy balance, and snowpack state variables are eliminated when there is no snowpack. Yearly totals (water year) are printed after September 30 for the accumulated precipitation, input, evapotranspiration, and generated runoff. The change in the recharge requirement since the beginning of the water year is also indicated. A sample output is on page D-2.

3. Yearly Totals (beginning 10/1 and ending 9/30) and Average Year (Use sheet B-3) - Prints one composite line per water year which lists the peak snowpack water equivalent, the recharge requirement on September 30 and the yearly totals (water year) for snowmelt generated runoff, precipitation, and evapotranspiration. It also prints the change in the recharge requirement since the beginning of the water year. If an alternative is processed, the changes in each of the above components caused by the alternative are also printed. While the yearly totals are being printed, the data are accumulated to compute an "average" year, which is printed in the interval sums format using a standard 6-day interval. The plot is for the average year only. A sample output is on page D-3.

4. Individual Stations - This method allows the user to print data for specified stations rather than for a composite of many stations. (Each station could be processed separately with a weight of 1.00, but this method of output allows the user to examine individual stations without constructing new decks.) The user may choose either interval sums, yearly totals - average year, or both, with the formats of the output being identical to those discussed above. A sample output is on page D-4.
   a. Interval sums (Use page B-5)
   b. Yearly totals and average year (Use page B-6)
   c. Both (Use page B-7)

B. Complete the sheet as follows:

1. Indicate the source of the data as cards or tape. (Only tapes built by the model or in the model format can be accepted. When cards are read, they are edited and the model builds a tape or a scratch file. A significant time savings on future runs is realized when the user supplies a tape to retain the data after the initial run.) If cards are specified, prepare page B-9 as follows (or let the operator prepare it):

a. Define the format of the card using FORTRAN specifications. Read all variables by F-type formats (dates are F2.0).

b. Indicate the order of the information on the card by numbering the items from 1 to 7. All items must be numbered and must have part in the format. (If the observed hydrograph data are not available, read a blank column by F1.0).

2. The output option code is preprinted on the page selected.

3. Enter the base for determining the time interval. (See discussion A-1 above for clarification.) The base must be between 1 and 31, inclusive.

4. The output sub-option code is preprinted on the appropriate pages.

5. Select the alternative desired. If only the normal simulation is wanted, leave the entire area blank. Complete the blanks pertaining to the alternative: express all percentages in decimal form (15 percent = .15, 50 percent = .50) and all dates with month and day only (1101, 0331).

   NOTE: The range of the clearcut percent is .10 through .75; values outside that range will abort the job. The range on thinning is 1 to 100%; a blank in the thinning columns is transformed to mean 100% as opposed to its normal value of 0.

6. Follow the instructions on the page selected. (These refer to page B-7 on which the user indicates the stations or units to be processed. Since the model identifies the units as 1, 2, 3, . . . in the order of the parameter deck, it is essential that the list order correspond to the deck order. Then, the appropriate blanks may be filled in with a 1 or left blank.) It is not necessary to complete page B-7 for a run which is processing only a normal simulation or only the weather modification alternative.

7. The plots or graphs will be printed with appropriate legends to identify each variable plotted. Five levels (separate plots) may be plotted simultaneously. The base lines for the plots are illustrated on page B-8, showing the dates as printing immediately below base line 1. All variables may print on any base line with the exception of the soil water deficit: It is represented by a negative number which prints below the base line, and may not be printed on base line 1.

More than one variable may be printed on a given base line, but confusion may arise in two cases: 1) if both "curves" fall in a given print position, only one symbol will appear; and 2) alternatives for all variables are printed with the symbol A (alternatives always print on the same base line as their normal counterpart.) The user should indicate the base line for each variable to be plotted; if left blank, the variable will not be plotted. If the alternative is to be plotted, fill in the appropriate blanks with a 1. The user may supply maximum values for each "curve" to obtain better scaling. The assumed maximums (in inches) are:

Observed hydrograph	0.3
Snowpack W.E.	30.0
Input	1.0
Evapotranspiration	0.3
Storage deficit	-10.6
Generated runoff	1.0

A sample plot is on pages D-5 and D-6.

TABLE 1

Number of Pages Generated (Including Plots)

Output Option	Normal Simulation	Normal + Alternative
Interval Sums	$N_1(\frac{8}{N_2} + 2)$	$N_1(\frac{15}{N_2} + 2)$
Daily Detailed Lists	$10N_1$	$17N_1$
Yearly Totals + Ave. Year	$\frac{N_1}{20} + 5$	$\frac{N_1}{10} + 5$
Individual Stations		
1. Interval Sums	$N_1N_3(\frac{8}{N_2} + 2)$	$N_1N_3(\frac{15}{N_2} + 2)$
2. Yearly Total + Ave. Year	$N_3(\frac{N_1}{20} + 5)$	$N_3(\frac{N_1}{10} + 5)$
3. Both 1 and 2	Sum of 1 and 2	Sum of 1 and 2

N_1 = Number of years to be processed (form A-1, #3)

N_2 = Date-divisible-by (form B-n, #3)

N_3 = Number of stations to be processed (form A-1, #3)

TABLE 2

Central Processor Time (Seconds of execution)

Output Option	Normal Simulation	Normal + Alternative
Interval Sums	$N_1N_3 + \frac{30}{N_2}$	$N_1N_3 + \frac{60}{N_2}$
Daily Detailed Lists	$N_1N_3 + 8$	$2N_1N_3 + 8$
Yearly Totals + Ave. Year	$\frac{4N_1N_3}{10} + 4$	$\frac{7N_1N_3}{10} + 4$
Individual Stations		
1. Interval Sums	$(1 + \frac{N_3}{10})(N_1N_3 + \frac{30}{N_2})$	$(1 + \frac{N_3}{10})(N_1N_3 + \frac{60}{N_2})$
2. Yearly Total + Ave. Year	$(1 + \frac{N_3}{10})(\frac{4N_1N_3}{10} + 4)$	$(1 + \frac{N_3}{10}) + (\frac{7N_1N_3}{10} + 4)$
3. Both 1 and 2	Sum of 1 and 2	Sum of 1 and 2

See previous page for definitions of N_1, N_2, and N_3.

WATERSHED DESCRIPTION

1. Watershed Name _____

_____ (1-60)*

2. Summer Precipitation adjustment _____ (71-74,nnnn)

3. Number of subunits _____ (76-77,nn)

Number of years _____ (79-80,nn)

* *

4. Potential Radiation-Horizontal Surface (POTENTIAL RAD)*

JUN 22		_____	(16-20,nnnnn)
JUN 1	JUL 12	_____	(21-25,nnnnn)
MAY 18	JUL 27	_____	(26-30,nnnnn)
MAY 3	AUG 10	_____	(31-35,nnnnn)
APR 19	AUG 25	_____	(36-40,nnnnn)
APR 4	SEP 9	_____	(41-45,nnnnn)
MAR 21	SEP 23	_____	(46-50,nnnnn)
MAR 7	OCT 8	_____	(51-55,nnnnn)
FEB 20	OCT 22	_____	(56-60,nnnnn)
FEB 7	NOV 5	_____	(61-65,nnnnn)
JAN 23	NOV 19	_____	(66-70,nnnnn)
JAN 10	DEC 3	_____	(71-75,nnnnn)
DEC 22		_____	(76-80,nnnnn)

*Numbers in parenthesis are column numbers, all cap names are card titles, and the n's represent the possible digits in the field with the carat (^) showing the assumed decimal location. The assumed decimal location may be overridden by actually including it in the number, but one digit is sacrificed in so doing.

SUBSTATION DESCRIPTION

1. Substation Name _____

_____ (*1-50*)

2. Substation Code_____ (*51-60*) 3. Area Weight_____ (*61-65*,nnnnn)

* *

(SUBSTATION CONSTANTS)

4. Trans. Coeff _____ (*21-25*,nnnnn) 5. Cover Density_____ (*26-30*,nnnnn)

6. Maximum Cov. Den____ (*31-35*,nnnnn) 7. Vegetation Type (check one) (*40*,n)

Open	_____	= 0 (zero)
Lodgepole pine	_____	= 1
Spruce-fir	_____	= 2
Deciduous	_____	= 3 (see 11)

8. Reflectivity Thr____ (*41-45*,nnnnn) 9. Melt Threshold _____ (*46-50*,nnnnn)

10. Wilting Point -_____ (*51-55*,nnnnn) 11. Deciduous Winter Values

Trans. Coeff	_____	(*56-60*,nnnnn)
Cov. Den	_____	(*61-65*,nnnnn)
Max. Cov. Den	_____	(*66-70*,nnnnn)

* *

(INITIAL CONDITIONS)

12. Initial Conditions

	Pack Temp. (nnnnn)	Pack W.E. (nnnnn)	Rech. Req. (nnnnn)	Control? (n)
Normal	_____ (*21-25*)	_____ (*26-30*)	-_____ (*31-35*)	_____ (*40*)
Area 1	_____ (*41-45*)	_____ (*46-50*)	-_____ (*51-55*)	_____ (*60*)
Area 2	_____ (*61-65*)	_____ (*66-70*)	-_____ (*71-75*)	_____ (*80*)

(DAILY ET)

13. Average Daily Evapotranspiration (nnnnn)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
(21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80)

* *

(AIR TEMP COEFF)

14. Air Temperature Regression Coefficients

Maximum: A _____ (*21-25*,nnnnn) B _____ (*26-30*,nnnnn)

Minimum: A _____ (*31-35*,nnnnn) B _____ (*36-40*,nnnnn)

* *

15. Slope/Aspect Adjustment Factors (SLØPE ASPECT)

JUN 22		_____	(*16-20*,nnnnn)
JUN 1	JUL 12	_____	(*21-25*,nnnnn)
MAY 18	JUL 27	_____	(*26-30*,nnnnn)
MAY 3	AUG 10	_____	(*31-35*,nnnnn)
APR 19	AUG 25	_____	(*36-40*,nnnnn)
APR 4	SEP 9	_____	(*41-45*,nnnnn)
MAR 21	SEP 23	_____	(*46-50*,nnnnn)
MAR 7	OCT 8	_____	(*51-55*,nnnnn)
FEB 20	OCT 22	_____	(*56-60*,nnnnn)
FEB 7	NOV 5	_____	(*61-65*,nnnnn)
JAN 23	NOV 19	_____	(*66-70*,nnnnn)
JAN 10	DEC 3	_____	(*71-75*,nnnnn)
DEC 22		_____	(*76-80*,nnnnn)

(SPECIFIED CONDITIONS)

16. Specified Conditions (1 line per year)

Peak W.E. (*21-25*) (nnnnn)	Accum Ppt (*26-30*) (nnnnn)	Date (*32-37*) (MMDDYY)	Isothermal Date (*39-44*) (MMDDYY)

(CONTINUE ON THE REVERSE SIDE)

PROCESSING TO BE PERFORMED

Output by Interval Sums

(SELECT)

1. Data are on (check one) _____ cards (Prepare page B-9 also) (5) _____ mag tape (1) (*8*,n)

2. Output option __2__ (*10*,n)

3. Date-divisible-by _____(*12-13*,nn)

4. Not applicable

5. Alternatives (Leave blank if only the normal simulation is wanted)

Alt (*20*,n)	Patch-cut % (*22-23*,nn)	Ppt Increase % (*25-26*,nn)	Thinning % (*28-29*,nn)	Dates of Seeding Start (*31-34*,MMDD)	Dates of Seeding End (*36-39*,MMDD)
(1) Clearcut	____				
(2) Weather Mod		____		____	____
(3) Clearcut & Weather Mod	____	____		____	____
(4) Thinning			____		
(5) Clearcut & Thinning	____		____		
(6) Weather Mod & Thinning	____	____	____	____	____
(7) Clearcut, Weather Mod & Thinning	____	____	____	____	____

6. If clearcutting or thinning, prepare page B-7 to indicate which stations are subject to the cutting.

7. Use page B-8

PROCESSING TO BE PERFORMED

Output by Daily Detailed Lists

(SELECT)

1. Data are on (check one) _____ cards (Prepare page B-9 also) (5) _____ mag tape (1) (*8*,n)

2. Output option 3 (*10*,n)

3. Not applicable

4. Not applicable

5. Alternatives (Leave blank if only the normal simulation is wanted)

Alt (*20*,n)	Clearcut % (*22-23*,nn)	Ppt Increase % (*25-26*,nn)	Thinning % (*28-29*,nn)	Dates of Seeding Start (*31-34*,MMDD)	Dates of Seeding End (*36-39*,MMDD)
(1) Clearcut	____				
(2) Weather Mod		____		____	____
(3) Clearcut & Weather Mod	____	____		____	____
(4) Thinning			____		
(5) Clearcut & Thinning	____		____		
(6) Weather Mod & Thinning		____	____	____	____
(7) Clearcut, Weather Mod & Thinning	____	____	____	____	____

6. If clearcutting or thinning, prepare page B-7 to indicate which stations are subject to cutting.

7. Use page B-8

PROCESSING TO BE PERFORMED

Output by Yearly Summaries & Average Year

(SELECT)

1. Data are on (check one) _____ cards (Prepare page B-9 also) (5) _____ mag tape (1) (*8*,n)

2. Output option ___4___ (*10*,n)

3. Not applicable

4. Not applicable

5. Alternatives (Leave blank if only the normal simulation is wanted)

Alt (*20*,n)	Clearcut % (*22-23*,nn)	Ppt Increase % (*25-26*,nn)	Thinning % (*28-29*,nn)	Dates of Seeding Start (*31-34*,MMDD)	Dates of Seeding End (*36-39*,MMDD)
(1) Clearcut	_____				
(2) Weather Mod		_____		_____	_____
(3) Clearcut & Weather Mod	_____	_____		_____	_____
(4) Thinning			_____		
(5) Clearcut & Thinning	_____		_____		
(6) Weather Mod & Thinning		_____	_____	_____	_____
(7) Clearcut, Weather Mod & Thinning	_____	_____	_____	_____	_____

6. If clearcutting or thinning, prepare page B-7 to indicate which stations are subject to the cutting.

7. Use page B-8

PROCESSING TO BE PERFORMED

Output by Individual Stations (Interval sums)

(SELECT)

1. Data are on (check one) _____ cards (Prepare page B-9 also) (5) _____ mag tape (1) (*8*,n)

2. Output option ____5____ (*10*,n)

3. Date-divisible-by _____ (*12-13*,nn)

4. Sub-option ____1____ (*17*,n)

5. Alternatives (Leave blank if only the normal simulation is wanted)

Alt (*20*,n)	Clearcut % (*22-23*,nn)	Ppt Increase % (*25-26*,nn)	Thinning % (*28-29*,nn)	Dates of Seeding Start (*31-34*,MMDD)	Dates of Seeding End (*36-39*,MMDD)
(1) Clearcut	_____				
(2) Weather Mod		_____		_____	_____
(3) Clearcut & Weather Mod	_____	_____		_____	_____
(4) Thinning			_____		
(5) Clearcut & Thinning	_____		_____		
(6) Weather Mod & Thinning		_____	_____	_____	_____
(7) Clearcut, Weather Mod & Thinning	_____	_____	_____	_____	_____

6. Use page B-7 to indicate the stations to be processed.

7. Use page B-8

PROCESSING TO BE PERFORMED

Output by Individual Stations (Yearly totals and average year)

(SELECT)

1. Data are on (check one) _____ cards (Prepare page B-9 also) (5) _____ mag tape (1) (*8*,n)
2. Output option ____5____ (*10*,n)
3. Not applicable
4. Sub-option ____2____ (*17*,n)
5. Alternatives (Leave blank if only the normal simulation is wanted)

Alt (*20*,n)	Clearcut % (*22-23*,nn)	Ppt Increase % (*25-26*,nn)	Thinning % (*28-29*,nn)	Dates of Seeding Start (*31-34*,MMDD)	Dates of Seeding End (*36-39*,MMDD)
(1) Clearcut	_____				
(2) Weather Mod		_____		_____	_____
(3) Clearcut & Weather Mod	_____	_____		_____	_____
(4) Thinning			_____		
(5) Clearcut & Thinning	_____		_____		
(6) Weather Mod & Thinning		_____	_____	_____	_____
(7) Clearcut, Weather Mod & Thinning	_____	_____	_____	_____	_____

6. Use page B-7 to indicate the stations to be processed.
7. Use page B-8

PROCESSING TO BE PERFORMED

Output by Individual Stations (Both Interval sums and yearly totals, average year)

(SELECT)

1. Data are on (check one) _____ cards (Prepare page B-9 also) (5) _____ mag tape (1) (*8*,n)

2. Output option 5 (*10*,n)

3. Date-divisible-by _____(*12-13*,nn)

4. Sub-option 3 (*17*,n)

5. Alternatives (Leave blank if only the normal simulation is wanted)

Alt (*20*,n)	Clearcut % (*22-23*,nn)	Ppt Increase % (*25-26*,nn)	Thinning % (*28-29*,nn)	Dates of Seeding Start (*31-34*,MMDD)	Dates of Seeding End (*36-39*,MMDD)
(1) Clearcut	_____				
(2) Weather Mod		_____		_____	_____
(3) Clearcut & Weather Mod	_____	_____		_____	_____
(4) Thinning			_____		
(5) Clearcut & Thinning	_____		_____		
(6) Weather Mod & Thinning		_____	_____	_____	_____
(7) Clearcut, WEather Mod & Thinning	_____	_____	_____	_____	_____

6. Use page B-7 to indicate the stations to be processed.

7. Use page B-8

PROCESSING TO BE PERFORMED

(SELECT)

Identification of Stations Subjected to Cutting or Stations to be Processed Individually

IMPORTANT: The list below must identify all substations in the same order as that of the substation cards when processed by the model. Identify all stations and check the ones to be cut or processed.

	Substation Code	Processed (1=yes)	
1	_____	_____	(*41*,n)
2	_____	_____	(*42*,n)
3	_____	_____	(*43*,n)
4	_____	_____	(*44*,n)
5	_____	_____	(*45*,n)
6	_____	_____	(*46*,n)
7	_____	_____	(*47*,n)
8	_____	_____	(*48*,n)
9	_____	_____	(*49*,n)
10	_____	_____	(*50*,n)
11	_____	_____	(*51*,n)
12	_____	_____	(*52*,n)
13	_____	_____	(*53*,n)
14	_____	_____	(*54*,n)
15	_____	_____	(*55*,n)
16	_____	_____	(*56*,n)
17	_____	_____	(*57*,n)
18	_____	_____	(*58*,n)
19	_____	_____	(*59*,n)
20	_____	_____	(*60*,n)
21	_____	_____	(*61*,n)
22	_____	_____	(*62*,n)
23	_____	_____	(*63*,n)
24	_____	_____	(*64*,n)
25	_____	_____	(*65*,n)

PROCESSING TO BE PERFORMED

PLOT SPECIFICATIONS

(PLØTS)

Base line 5 . . . . . .

4 . . . . . .

3 . . . . . .

2 . . . . . .

1 . . . . . .

DATE DATE

Item	Base Line	Alternative Also?(1=yes)	Maximum Value
Obs Hydrograph	_____ (*10*,n)		_____ (*31-35*,nnnnn)
Snowpack W.E.	_____ (*12*,n)	_____ (*22*,n)	_____ (*36-40*,nnnnn)
Input	_____ (*14*,n)	_____ (*24*,n)	_____ (*41-45*,nnnnn)
Evapotranspiration	_____ (*16*,n)	_____ (*26*,n)	_____ (*46-50*,nnnnn)
Storage (may not plot on base line 1 since it plots below the line)	_____ (*18*,n)	_____ (*28*,n)	_____ (*51-55*,-nnnn)
Runoff	_____ (*20*,n)	_____ (*30*,n)	_____ (*56-60*,nnnnn)

PROCESSING TO BE PERFORMED

Input Card Format

Variable Format (may be completed by operator)

IMPORTANT - all variables, including dates, must be read by F-type formats.

(_____

_____) (1-70)

Relative order on the card (Number 1 to 7)

Month	_____	(74,n)
Day	_____	(75,n)
Year	_____	(76,n)
Maximum Temp.	_____	(77,n)
Minimum Temp.	_____	(78,n)
Precipitation	_____	(79,n)
Observed Hydrograph	_____	(80,n)

WATER BALANCE SIMULATION

SAMPLE WATERSHED, CENTRAL COLORADO ROCKIES — COMPOSITE OF 4 SUBSTATIONS

	CURRENT SNOWPACK W. E.	CURRENT RECHARGE REQ	INTERVAL TOTALS PRECIP	INPUT	EVAPOTRANS	FROM	GENERATED RUNOFF	YEAR TO DATE PRECIP	INPUT	EVAPOTRANS	GEN RUNOFF	CHANGE IN RECHRG RQ
7 10 65	0.00	-2.23	.46	.75	1.5276	E	.18	27.70	22.53	9.9958	16.54	1.17
ALT 1	0.00	-1.91	.46	.46	1.0186	E	0.00	27.70	22.80	9.3462	17.80	.55
7 20 65	0.00	-2.46	.91	.91	1.1402	E	0.00	28.61	23.44	11.1361	16.54	.94
ALT 1	0.00	-1.88	.91	.91	.8477	E	.03	28.61	23.71	10.1939	17.83	.59
7 30 65	0.00	-1.69	2.42	2.42	1.3948	E	.25	31.03	25.86	12.5309	16.79	1.71
ALT 1	0.00	-1.51	2.42	2.42	1.0831	E	.97	31.03	26.13	11.2770	18.80	.95
8 10 65	0.00	-2.41	.72	.72	1.3919	E	.05	31.75	26.58	13.9228	16.84	.99
ALT 1	0.00	-2.05	.72	.72	1.0355	E	.23	31.75	26.85	12.3125	19.03	.41
8 20 65	.01	-2.04	1.43	1.42	.9786	E	.07	33.18	28.00	14.9015	16.91	1.36
ALT 1	.01	-1.75	1.43	1.42	.7155	E	.40	33.18	28.27	13.0280	19.42	.72
8 30 65	0.00	-2.82	.24	.25	1.0289	E	.00	33.42	28.25	15.9303	16.91	.58
ALT 1	0.00	-2.31	.24	.25	.7932	E	.02	33.42	28.52	13.8213	19.44	.16
9 10 65	0.00	-2.85	.54	.54	.5830	C E	0.00	33.97	28.79	16.5133	16.91	.55
ALT 1	0.00	-2.26	.55	.55	.4823	C E	.02	33.97	29.07	14.3035	19.46	.21
9 20 65	.59	-3.06	.75	.09	.3727	C E	0.00	34.72	28.88	16.8660	16.91	.34
	.62	-2.45	.75	.09	.3225	C E	0.00	34.72	29.16	14.6260	19.46	.01
	.90	-2.67	.93	.54	.2232	C E	0.00	35.65	29.42	17.1092	16.91	.73
	.92	-2.14	.93	.59	.2355	C E	.09	35.65	29.75	14.8615	19.55	.32
	.50	-2.62	.03	.43	.3767	C E	0.00	.03	.43	.3767	0.00	.05
	.51	-2.11	.03	.43	.2834	C E	.12	.03	.43	.2834	.12	.03
	.73	-2.83	.32	.06	.2982	C E	0.00	.34	.48	.6748	0.00	-.16
	.76	-2.28	.32	.06	.2330	C E	0.00	.34	.49	.5164	.12	-.13
	.73	-3.05	0.00	0.00	.2167	E	0.00	.34	.48	.8915	0.00	-.38
	.76	-2.46	0.00	0.00	.1826	E	0.00	.34	.49	.6990	.12	-.32
	.81	-3.14	.10	0.00	.1173	C S E	0.00	.45	.48	1.0088	0.00	-.47
	.84	-2.53	.10	0.00	.0931	C S E	0.00	.45	.49	.7921	.12	-.39
	2.22	-3.16	1.55	0.00	.1603	C S E	0.00	2.00	.48	1.1691	0.00	-.49
	2.29	-2.55	1.55	0.00	.1160	C S E	0.00	2.00	.49	.9081	.12	-.40
11 30 65	4.35	-3.16	2.29	0.00	.1614	C S E	0.00	4.29	.48	1.3305	0.00	-.49
ALT 1	4.47	-2.55	2.29	0.00	.1181	C S E	0.00	4.29	.49	1.0262	.12	-.41
12 10 65	4.41	-3.18	.11	0.00	.0652	C S E	0.00	4.39	.48	1.3957	0.00	-.51
ALT 1	4.51	-2.56	.11	0.00	.0781	C S E	0.00	4.39	.49	1.1043	.12	-.42
12 20 65	4.86	-3.18	.51	0.00	.0631	C S E	0.00	4.90	.48	1.4589	0.00	-.52
ALT 1	4.96	-2.56	.51	0.00	.0586	C S E	0.00	4.90	.49	1.1630	.12	-.42
12 30 65	5.63	-3.19	.87	0.00	.0832	C S E	0.00	5.77	.48	1.5421	0.00	-.52
ALT 1	5.75	-2.57	.87	0.00	.0781	C S E	0.00	5.77	.49	1.2411	.12	-.43
1 10 66	5.83	-3.19	.25	0.00	.0791	C S	0.00	6.02	.48	1.6213	0.00	-.52
ALT 1	5.94	-2.57	.25	0.00	.0769	C S E	0.00	6.02	.49	1.3180	.12	-.43
1 20 66	6.61	-3.19	.87	0.00	.0922	C S	0.00	6.90	.48	1.7134	0.00	-.52
ALT 1	6.74	-2.57	.87	0.00	.0764	C S E	0.00	6.90	.49	1.3944	.12	-.43
1 30 66	6.72	-3.19	.17	0.00	.0536	C S	0.00	7.06	.48	1.7670	0.00	-.52
ALT 1	6.84	-2.57	.17	0.00	.0561	C S	0.00	7.06	.49	1.4505	.12	-.43
2 10 66	7.61	-3.19	1.03	0.00	.1255	C S	0.00	8.09	.48	1.8925	0.00	-.52
ALT 1	7.76	-2.57	1.04	0.00	.1077	C S	0.00	8.09	.49	1.5583	.12	-.43
2 20 66	8.29	-3.19	.79	0.00	.1164	C S	0.00	8.88	.48	2.0089	0.00	-.52
ALT 1	8.45	-2.57	.79	0.00	.1018	C S	0.00	8.88	.49	1.6600	.12	-.43
3 10 66	8.59	-3.19	.64	0.00	.3258	C S	0.00	9.51	.48	2.3347	0.00	-.52
ALT 1	8.72	-2.57	.64	0.00	.3579	C S	0.00	9.51	.49	2.0179	.12	-.43
3 20 66	8.89	-3.19	.59	0.00	.2968	C S	0.00	10.10	.48	2.6315	0.00	-.52
ALT 1	9.00	-2.57	.59	0.00	.3126	C S	0.00	10.10	.49	2.3305	.12	-.43

Sample Output of Interval Sums

ALTERNATIVE 1 = CLEARCUT 40 PERCENT OF WATERSHED (CREATING SMALL FOREST OPENINGS, 5-TREE HEIGHTS IN DIAMETER) AND REDISTRIBUTE TH
PRECIPITATION (30 PERCENT INCREASE IN THE OPENINGS, 20 PERCENT DECREASE UNDER THE CANOPY)

WATERSHED DESCRIPTION

1. Watershed Name SAMPLE WATERSHED, CENTRAL COLORADO ROCKIES (1-60)*

2. Summer Precipitation adjustment 1.00 (71-74,nn^nn)

3. Number of subunits 4 (76-77,nn)

Number of years 2 (79-80,nn)

* *

4. Potential Radiation-Horizontal Surface (POTENTIAL RAD)*

JUN 22		1023	(16-20,nnn^nn)
JUN 1	JUL 12	1004	(21-25,nnn^nn)
MAY 18	JUL 27	972	(26-30,nnn^nn)
MAY 3	AUG 10	924	(31-35,nnn^nn)
APR 19	AUG 25	861	(36-40,nnn^nn)
APR 4	SEP 9	786	(41-45,nnn^nn)
MAR 21	SEP 23	703	(46-50,nnn^nn)
MAR 7	OCT 8	616	(51-55,nnn^nn)
FEB 20	OCT 22	532	(56-60,nnn^nn)
FEB 7	NOV 5	457	(61-65,nnn^nn)
JAN 23	NOV 19	396	(66-70,nnn^nn)
JAN 10	DEC 3	354	(71-75,nnn^nn)
DEC 22		329	(76-80,nnn^nn)

*Numbers in parenthesis are column numbers, all cap names are card titles, and the n's represent the possible digits in the field with the carat (^) showing the assumed decimal location. The assumed decimal location may be overridden by actually including it in the number, but one digit is sacrificed in so doing.

SAMPLE A-1

PROCESSING TO BE PERFORMED

Input Card Format

Variable Format (may be completed by operator)

IMPORTANT - all variables, including dates, must be read by F-type formats.

(3F2.0, 11X2F4.1, 19XF5.2, 5XF5.2)

) (1-70)

Relative order on the card (Number 1 to 7)

Month	1	(74,n)
Day	2	(75,n)
Year	3	(76,n)
Maximum Temp.	4	(77,n)
Minimum Temp.	5	(78,n)
Precipitation	6	(79,n)
Observed Hydrograph	7	(80,n)

8-7

SAMPLE B-9

SUBSTATION DESCRIPTION

1. Substation Name SPRUCE-FIR, 40 PERCENT SLOPE, NE ASPECT (1-50)

2. Substation Code S2-NE,FOR (51-60) 3. Area Weight .30 (61-65, nnnnn)

* *

(SUBSTATION CONSTANTS)

4. Trans. Coeff. .55 (21-25, nnnnn) 5. Cover Density .25 (26-30, nnnnn)

6. Maximum Cov. Den. .25 (31-35, nnnnn) 7. Vegetation Type (check one) (40, n)

Open		= 0 (zero)
Lodgepole pine		= 1
Spruce-fir	✓	= 2
Deciduous		= 3 (see 11)

8. Reflectivity Thr. 32 (41-45, nnnnn) 9. Melt Threshold 42 (46-50, nnnnn)

10. Wilting Point -5.3 (51-55, nnnnn) 11. Deciduous Winter Values

Trans. Coeff. _____ (56-60, nnnnn)
Cov. Den. _____ (61-65, nnnnn)
Max. Cov. Den. _____ (66-70, nnnnn)

* *

(INITIAL CONDITIONS)

12. Initial Conditions

	Pack Temp. (nnnnn)	Pack W.E. (nnnnn)	Rech. Req. (nnnnn)	Control? (n)
Normal	0.00 (21-25)	0.00 (26-30)	- 3.7 (31-35)	0 (40)
Area 1	0.00 (41-45)	0.00 (46-50)	- 3.7 (51-55)	0 (60)
Area 2	0.00 (61-65)	0.00 (66-70)	- 1.1 (71-75)	0 (80)

SAMPLE A-2

C-2

(DAILY ET)

13. Average Daily Evapotranspiration

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
.0167	.0242	.0451	.0812	.1524	.2204	.2791	.2094	.1188	.0581	.0266	.0140
(21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80)

* *

(AIR TEMP COEFF)

14. Air Temperature Regression Coefficients

Maximum: A -4.952 (21-25,nn^nn) B .886 (26-30,nn^nn)

Minimum: A -.227 (31-35,nn^nn) B 1.004 (36-40,nn^nn)

* *

15. Slope/Aspect Adjustment Factors

JUN 22		.94	(16-20,nn^nn)
JUN 1	JUL 12	.93	(21-25,nn^nn)
MAY 18	JUL 27	.91	(26-30,nn^nn)
MAY 3	AUG 10	.88	(31-35,nn^nn)
APR 19	AUG 25	.84	(36-40,nn^nn)
APR 4	SEP 9	.80	(41-45,nn^nn)
MAR 21	SEP 23	.75	(46-50,nn^nn)
MAR 7	OCT 8	.69	(51-55,nn^nn)
FEB 20	OCT 22	.62	(56-60,nn^nn)
FEB 7	NOV 5	.56	(61-65,nn^nn)
JAN 23	NOV 19	.49	(66-70,nn^nn)
JAN 10	DEC 3	.44	(71-75,nn^nn)
DEC 22		.41	(76-80,nn^nn)

SAMPLE A-3

C-3

(SPECIFIC CONDITIONS)

16. Specified Conditions (1 line per year)

Peak W.E. (21-25) (nnnnn)	Accum Ppt (26-30) (nnnnn)	Date (32-37) (MMDDYY)	Isothermal Date (39-44) (MMDDYY)
23.5		033165	051065
12.2		033066	051566

(CONTINUE ON THE REVERSE SIDE)

SAMPLE A-4
C-4

PROCESSING TO BE PERFORMED

Output by Interval Sums

(SELECT)

1. Data are on (check one) ✓ cards (Prepare page B-9 also) (5) _____ mag tape (1) (*8*,n)
2. Output option 2 (*10*,n)
3. Date-divisible-by 10 (*12-13*,nn)
4. Not applicable
5. Alternatives (Leave blank if only the normal simulation is wanted)

Alt (*20*,n)	Patch-cut % (*22-23*,nn)	Ppt Increase % (*25-26*,nn)	Thinning % (*28-29*,nn)	Dates of Seeding Start (*31-34*,MMDD)	Dates of Seeding End (*36-39*,MMDD)
(1) Clearcut	40				
(2) Weather Mod					
(3) Clearcut & Weather Mod					
(4) Thinning					
(5) Clearcut & Thinning					
(6) Weather Mod & Thinning					
(7) Clearcut, Weather Mod & Thinning					

6. If clearcutting or thinning, prepare page B-7 to indicate which stations are subject to the cutting.
7. Use page B-8

SAMPLE B-1

C-5

PROCESSING TO BE PERFORMED

(SELECT)

Identification of Stations Subjected to Cutting or Stations to be Processed Individually

IMPORTANT: The list below must identify all substations in the same order as that of the substation cards when processed by the model. Identify all stations and check the ones to be cut or processed.

	Substation Code	Processed (1=yes)			Substation Code	Processed (1=yes)	
1	S1-HORZ	1	(41,n)	16			(56,n)
2	S2-NE,FOR	1	(42,n)	17			(57,n)
3	S3-NE,OPEN		(43,n)	18			(58,n)
4	S4-SSE	1	(44,n)	19			(59,n)
5			(45,n)	20			(60,n)
6			(46,n)	21			(61,n)
7			(47,n)	22			(62,n)
8			(48,n)	23			(63,n)
9			(49,n)	24			(64,n)
10			(50,n)	25			(65,n)
11			(51,n)				
12			(52,n)				
13			(53,n)				
14			(54,n)				
15			(55,n)				

B-7 SAMPLE

C-6

PROCESSING TO BE PERFORMED

PLOT SPECIFICATIONS

(PLØTS)

Base line 5 . . . . . .

4 . . . . . .

3 . . . . . .

2 . . . . . .

1 . . . . . .

C-7

DATE DATE

Item	Base Line	Alternative Also?(1=yes)	Maximum Value
Obs Hydrograph	5 (10,n)		____ (31-35,nnnnn)
Snowpack W.E.	4 (12,n)	1 (22,n)	____ (36-40,nnnnn)
Input	1 (14,n)	1 (24,n)	____ (41-45,nnnnn)
Evapotranspiration	3 (16,n)	1 (26,n)	____ (46-50,nnnnn)
Storage (may not plot on base line 1 since it plots below the line)	2 (18,n)	1 (28,n)	____ (51-55,-nnnn)
Runoff	2 (20,n)	1 (30,n)	____ (56-60,nnnnn)

SAMPLE B-8

WATER BALANCE SIMULATION

SAMPLE WATERSHED, CENTRAL COLORADO ROCKIES — COMPOSITE OF 4 SUBSTATIONS

DATE	TEMP (F) MAX	MIN	AVE	PRECIP (IN) DAY	ACCUM	INTERCEPTED (IN)	RAD (CAL) SW	LW	INP BAL (CAL)	SNOWPACK TEMP(C)	WE(IN)	INPUT (IN)	EVAPOTRANS (IN)	FROM	RECHARGE REQ (IN)	GENERATED RUNOFF (IN)
9 30 65	34	19	27	0.00	35.65	0.0000	20.0	-20.0	0.0	-0.0	.90	0.00	.0279	E	-2.67	
ALT 1	34	19	27	0.00	35.65	0.0000	29.2	-29.2	0.0	-0.0	.92	0.00	.0208	E	-2.14	
TOTALS THROUGH 9 30 65					35.65							29.42	17.1092	(CHNG =	.73)	16.91
ALT 1					35.65							29.75	14.8615		.32	19.55
10 1 65	47	16	31	.01	.01	0.0000	75.7	-75.7	0.0	-0.0	.91	0.00	.0022	C E	-2.67	
ALT 1	47	16	31	.01	.01	0.0000	99.2	-99.2	0.0	-0.0	.93	0.00	.0109	C E	-2.15	
10 2 65	61	21	41	.01	.03	0.0000	104.5	-80.0	24.4	-0.0	.81	.11	.0025	C E	-2.56	
ALT 1	61	21	41	.01	.03	0.0000	134.7	-96.3	38.4	-0.0	.76	.18	.0130	C E	-2.06	.09
10 3 65	61	24	43	0.00	.03	0.0000	27.1	-15.9	11.2	-0.0	.64	.18	.0499	E	-2.43	
ALT 1	61	24	43	0.00	.03	0.0000	38.8	-19.2	19.6	-0.0	.65	.11	.0351	E	-2.02	.04
10 4 65	60	26	43	0.00	.03	0.0000	17.7	-17.7	0.0	-0.0	.61	.03	.0491	E	-2.45	
ALT 1	60	26	43	0.00	.03	0.0000	21.3	-21.3	0.0	-0.0	.65	.00	.0342	E	-2.05	
10 5 65	56	23	40	0.00	.03	0.0000	18.0	-18.0	0.0	-0.0	.61	0.00	.0466	E	-2.50	
ALT 1	56	23	40	0.00	.03	0.0000	21.7	-21.7	0.0	-0.0	.65	0.00	.0324	E	-2.09	
10 6 65	53	24	39	0.00	.03	0.0000	18.7	-18.7	0.0	-0.0	.61	0.00	.0444	E	-2.54	
ALT 1	53	24	39	0.00	.03	0.0000	22.5	-22.5	0.0	-0.0	.65	0.00	.0308	E	-2.12	
	56	28	42	0.00	.03	0.0000	21.0	-21.0	0.0	-0.0	.61	0.00	.0447	E	-2.59	
	56	28	42	0.00	.03	0.0000	25.2	-25.2	0.0	-0.0	.65	0.00	.0308	E	-2.15	
	58	24	41	0.00	.03	0.0000	22.0	-22.0	0.0	-0.0	.61	0.00	.0445	E	-2.63	
	58	24	41	0.00	.03	0.0000	26.5	-26.5	0.0	-0.0	.65	0.00	.0304	E	-2.18	
	88	23	56	0.00	.03	0.0000	25.8	0.0	25.8	-0.0	.50	.11	.0485	E	-2.57	
	88	23	56	0.00	.03	0.0000	31.1	0.0	31.1	-0.0	.51	.13	.0345	E	-2.08	
	61	24	43	0.00	.03	0.0000	23.5	-23.5	0.0	-0.0	.50	0.00	.0443	E	-2.62	
	61	24	43	0.00	.03	0.0000	28.3	-28.3	0.0	-0.0	.51	0.00	.0314	E	-2.11	
	57	24	41	0.00	.03	0.0000	22.6	-22.6	0.0	-0.0	.50	0.00	.0420	E	-2.66	
	57	24	41	0.00	.03	0.0000	27.2	-27.2	0.0	-0.0	.51	0.00	.0296	E	-2.14	
	54	23	39	0.00	.03	0.0000	21.6	-21.6	0.0	-0.0	.50	0.00	.0400	E	-2.70	
	54	23	39	0.00	.03	0.0000	26.0	-26.0	0.0	-0.0	.51	0.00	.0281	E	-2.17	
	57	19	38	0.00	.03	0.0000	23.1	-23.1	0.0	-0.0	.50	0.00	.0403	E	-2.74	
	57	19	38	0.00	.03	0.0000	27.8	-27.8	0.0	-0.0	.51	0.00	.0282	E	-2.20	
	59	24	42	0.00	.03	0.0000	23.9	-23.9	0.0	-0.0	.50	0.00	.0401	E	-2.78	
	59	24	42	0.00	.03	0.0000	28.8	-28.8	0.0	-0.0	.51	0.00	.0279	E	-2.23	
	59	24	42	0.00	.03	0.0000	24.1	-24.1	0.0	-0.0	.50	0.00	.0393	E	-2.82	
ALT 1	59	24	42	0.00	.03	0.0000	29.1	-29.1	0.0	-0.0	.51	0.00	.0272	E	-2.25	
10 16 65	54	32	43	0.00	.03	0.0000	22.4	-22.4	0.0	-0.0	.50	0.00	.0259	E	-2.84	
ALT 1	54	32	43	0.00	.03	0.0000	27.0	-27.0	0.0	-0.0	.51	0.00	.0231	E	-2.28	
10 17 65	56	29	42	0.00	.03	0.0000	23.5	-23.5	0.0	-0.0	.50	0.00	.0260	E	-2.87	
ALT 1	56	29	42	0.00	.03	0.0000	28.3	-28.3	0.0	-0.0	.51	0.00	.0227	E	-2.30	
10 18 65	40	32	36	.17	.20	0.0000	30.8	-30.8	0.0	-0.0	.63	.03	.0157	C E	-2.84	
ALT 1	40	32	36	.17	.20	0.0000	40.5	-40.5	0.0	-0.0	.65	.03	.0158	C E	-2.28	
10 19 65	39	32	36	.14	.34	0.0000	30.0	-30.0	0.0	-0.0	.73	.03	.0132	C E	-2.82	
ALT 1	39	32	36	.14	.34	0.0000	39.4	-39.4	0.0	-0.0	.76	.03	.0146	C E	-2.26	
10 20 65	41	20	31	0.00	.34	0.0000	21.6	-21.6	0.0	-0.0	.73	0.00	.0157	E	-2.83	
ALT 1	41	20	31	0.00	.34	0.0000	31.1	-31.1	0.0	-0.0	.76	0.00	.0157	E	-2.28	
10 21 65	48	16	32	0.00	.34	0.0000	34.7	-34.7	0.0	-0.0	.73	0.00	.0216	E	-2.85	
ALT 1	48	16	32	0.00	.34	0.0000	49.0	-49.0	0.0	-0.0	.76	0.00	.0198	E	-2.30	
10 22 65	51	20	36	0.00	.34	0.0000	41.8	-41.8	0.0	-0.0	.73	0.00	.0233	E	-2.88	
ALT 1	51	20	36	0.00	.34	0.0000	58.8	-58.8	0.0	-0.0	.76	0.00	.0207	E	-2.32	

Sample Output of Daily Detailed Lists

ALTERNATIVE 1 - CLEARCUT 40 PERCENT OF WATERSHED (CREATING SMALL FOREST OPENINGS, 5-TREE HEIGHTS IN DIAMETER) AND REDISTRIBUTE THE PRECIPITATION (30 PERCENT INCREASE IN THE OPENINGS, 20 PERCENT DECREASE UNDER THE CANOPY)

WATER BALANCE SIMULATION - YEARLY SUMMARY

SAMPLE WATERSHED, CENTRAL COLORADO ROCKIES

	PEAK RE	RECHARGE REQ 9/30	GENERATED RUNOFF	PRECIP	EVAPOTR	CHANGE IN RECH. REQ
1965	19.82	-2.67	16.91	35.65	17.11	.73
ALT 1	20.06	-2.14	19.55	35.65	14.86	.32
CHANGE	.24	.53	2.64	0.00	-2.25	-.41
1966	9.83	-3.41	6.74	21.44	16.24	-.74
ALT 1	9.97	-2.34	8.10	21.44	14.36	-.20
CHANGE	.14	1.07	1.36	0.00	-1.89	.54

ALTERNATIVE 1 - CLEARCUT 40 PERCENT OF WATERSHED (CREATING SMALL FOREST OPENINGS, 5-TREE HEIGHTS IN DIAMETER) AND REDISTRIBUTE THE PRECIPITATION (30 PERCENT INCREASE IN THE OPENINGS, 20 PERCENT DECREASE UNDER THE CANOPY)

Sample Output of Annual Totals

WATER BALANCE SIMULATION

SAMPLE WATERSHED, CENTRAL COLORADO ROCKIES — SPRUCE-FIR, 40 PERCENT SLOPE, NORTHEAST ASPECT — SCENE, FOR

Sample Output of Individual Station by Interval Sums

	CURRENT SNOWPACK W. E.	RECHARGE REQ	INTERVAL TOTALS PRECIP	INPUT	EVAPOTRANS	FROM	GENERATED RUNOFF	YEAR TO DATE PRECIP	INPUT	EVAPOTRANS	GEN RUNOFF	CHANGE IN RECHRG RQ
7 10 65	0.00	-.63	.46	1.43	1.4552	E	.61	31.92	26.70	7.9197	20.94	3.07
ALT 1	0.00	-1.27	.46	.46	1.0625	E	0.00	31.92	27.41	7.4623	23.07	1.39
7 20 65	0.00	-1.04	.91	.91	1.3160	E	0.00	32.83	27.61	9.2357	20.94	2.66
ALT 1	0.00	-1.47	.91	.91	1.0271	E	.08	32.83	28.32	8.4894	23.15	1.19
7 30 65	0.00	-.17	2.42	2.42	1.2456	E	.31	35.25	30.03	10.4813	21.25	3.53
ALT 1	0.00	-1.06	2.42	2.42	1.0214	E	.98	35.25	30.74	9.5108	24.14	1.60
8 10 65	0.00	-.72	.72	.72	1.2344	E	.03	35.97	30.75	11.7157	21.28	2.98
ALT 1	0.00	-1.57	.72	.72	.9973	E	.23	35.97	31.46	10.5081	24.37	1.09
	.03	-.46	1.43	1.40	1.1413	E	0.00	37.40	32.15	12.8570	21.28	3.24
	.03	-1.45	1.43	1.40	.8388	E	.44	37.40	32.86	11.3469	24.81	1.21
	0.00	-1.28	.24	.27	1.0876	E	0.00	37.64	32.42	13.9446	21.28	2.42
	0.00	-2.04	.24	.27	.8328	E	.03	37.64	33.13	12.1797	24.84	.62
	0.00	-1.36	.55	.53	.6323	C E	0.00	38.19	32.95	14.5769	21.28	2.34
	0.00	-2.00	.55	.54	.4523	E	.06	38.19	33.67	12.6319	24.90	.66
	.64	-1.69	.75	0.00	.4432	C E	0.00	38.94	32.95	15.0201	21.28	2.01
	.70	-2.25	.75	0.00	.3061	E	0.00	38.94	33.67	12.9380	24.90	.41
	1.43	-1.81	.93	0.00	.2595	C E	0.00	39.87	32.95	15.2796	21.28	1.89
	1.56	-2.36	.93	0.00	.1802	E	0.00	39.87	33.67	13.1182	24.90	.30
	1.24	-1.87	.03	.22	.2720	C E	0.00	.03	.22	.2720	0.00	-.05
	1.29	-2.21	.03	.30	.1507	E	0.00	.03	.30	.1507	0.00	.15
	1.56	-2.10	.37	0.00	.2911	C E	0.00	.40	.22	.5631	0.00	-.29
	1.63	-2.35	.37	0.00	.1622	E	0.00	.40	.30	.3129	0.00	.02
	1.56	-2.38	0.00	0.00	.2740	E	0.00	.40	.22	.8371	0.00	-.56
	1.63	-2.49	0.00	0.00	.1386	E	0.00	.40	.30	.4515	0.00	-.12
	1.66	-2.49	.12	0.00	.1349	C E	0.00	.52	.22	.9721	0.00	-.68
	1.74	-2.54	.12	0.00	.0639	E	0.00	.52	.30	.5154	0.00	-.18
11 20 65	3.31	-2.50	1.82	0.00	.1798	C E	0.00	2.34	.22	1.1519	0.00	-.69
ALT 1	3.46	-2.55	1.82	0.00	.1117	E	0.00	2.34	.30	.6271	0.00	-.19
11 30 65	5.84	-2.51	2.69	0.00	.1560	CSE	0.00	5.03	.22	1.3079	0.00	-.69
ALT 1	6.05	-2.56	2.69	0.00	.1063	SE	0.00	5.03	.30	.7334	0.00	-.19
12 10 65	5.93	-2.51	.12	0.00	.0301	CS	0.00	5.16	.22	1.3380	0.00	-.69
ALT 1	6.15	-2.56	.12	0.00	.0250	S	0.00	5.16	.30	.7584	0.00	-.20
12 20 65	6.46	-2.51	.59	0.00	.0665	CS	0.00	5.74	.22	1.4045	0.00	-.69
ALT 1	6.69	-2.56	.59	0.00	.0511	S	0.00	5.74	.30	.8095	0.00	-.20
12 30 65	7.32	-2.51	1.01	0.00	.0673	CS	0.00	6.75	.22	1.4718	0.00	-.69
ALT 1	7.61	-2.56	1.01	0.00	.0483	S	0.00	6.75	.30	.8578	0.00	-.20
1 10 66	7.63	-2.51	.29	0.00	.0612	CS	0.00	7.04	.22	1.5330	0.00	-.69
ALT 1	7.89	-2.56	.29	0.00	.0502	S	0.00	7.04	.30	.9080	0.00	-.20
1 20 66	8.53	-2.51	1.00	0.00	.0935	CS	0.00	8.04	.22	1.6265	0.00	-.69
ALT 1	8.82	-2.56	1.00	0.00	.0672	S	0.00	8.04	.30	.9752	0.00	-.20
1 30 66	8.68	-2.51	.19	0.00	.0439	CS	0.00	8.23	.22	1.6703	0.00	-.69
ALT 1	8.97	-2.56	.19	0.00	.0359	S	0.00	8.23	.30	1.0111	0.00	-.20
2 10 66	9.65	-2.51	1.16	0.00	.1454	CS	0.00	9.39	.22	1.8157	0.00	-.69
ALT 1	10.02	-2.56	1.16	0.00	.1033	S	0.00	9.39	.30	1.1143	0.00	-.20
2 20 66	10.46	-2.51	.91	0.00	.1429	CS	0.00	10.30	.22	1.9585	0.00	-.69
ALT 1	10.84	-2.56	.91	0.00	.1004	S	0.00	10.30	.30	1.2147	0.00	-.20
3 10 66	10.95	-2.51	.67	0.00	.1823	CS	0.00	10.97	.22	2.1408	0.00	-.69
ALT 1	11.35	-2.56	.67	0.00	.1591	S	0.00	10.97	.30	1.3738	0.00	-.20
3 20 66	11.32	-2.51	.56	0.00	.1883	CS	0.00	11.53	.22	2.3291	0.00	-.69
ALT 1	11.74	-2.56	.56	0.00	.1747	S	0.00	11.53	.30	1.5486	0.00	-.20

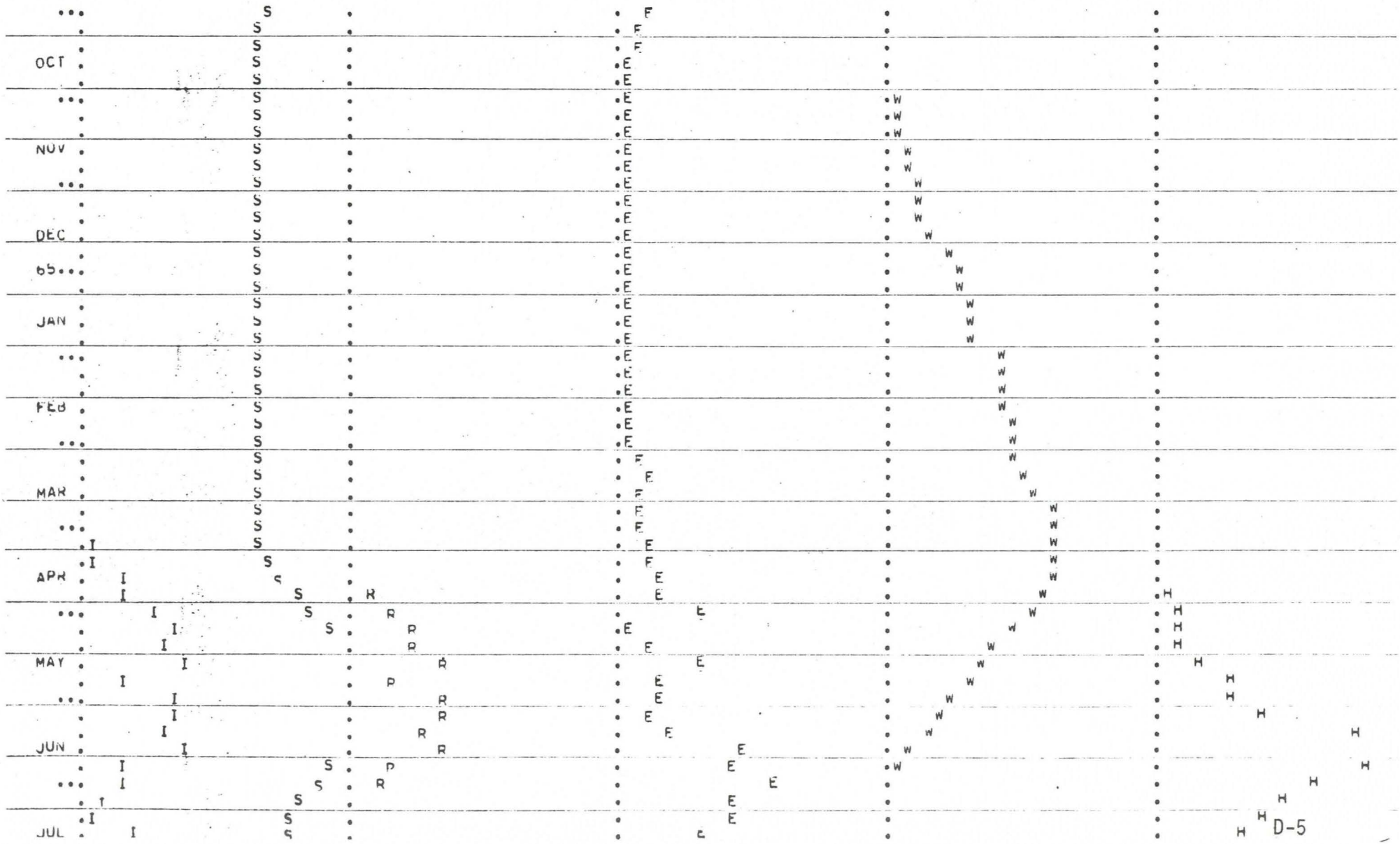
ALTERNATIVE 1 = CLEARCUT 40 PERCENT OF WATERSHED (CREATING SMALL FOREST OPENINGS, 5-TREE HEIGHTS IN DIAMETER) AND REDISTRIBUTE THE PRECIPITATION (30 PERCENT INCREASE IN THE OPENINGS, 20 PERCENT DECREASE UNDER THE CANOPY)

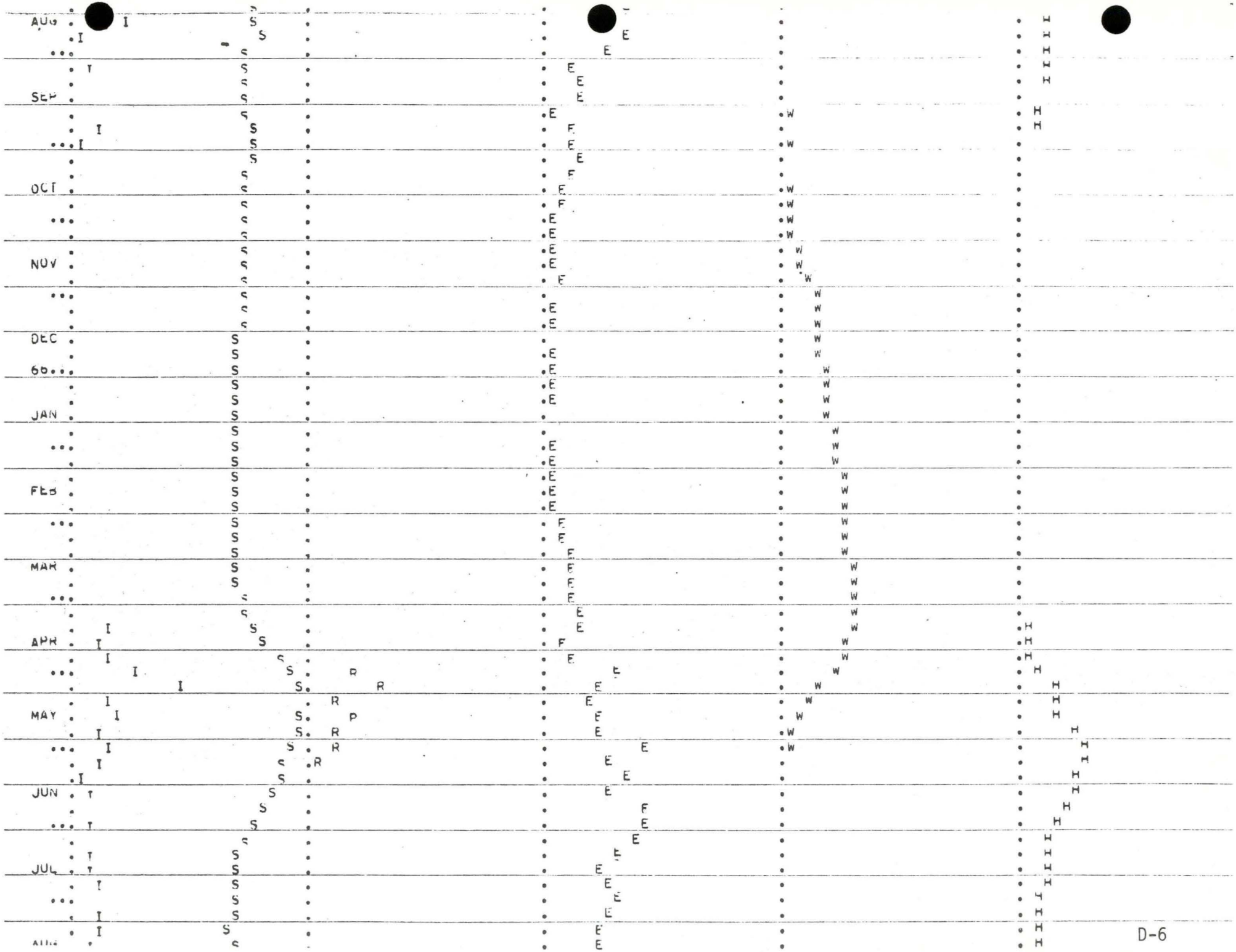
SAMPLE WATERSHED, CENTRAL COLORADO ROCKIES — WATER [illegible] STATION — COMPOSITE OF 4 STATIONS

Sample Plot

LEGEND

CHAR	DEFINITION	RANGE
A	ALTERNATIVE RESULT FOR NEAREST CHARACTER	
E	EVAPOTRANSPIRATION	0 TO .3 INCH
H	HYDROGRAPH-OBSERVED	0 TO .3 AREA INCHES
I	INPUT - MELT OR RAIN	0 TO 1.0 INCHES
R	RUNOFF-SIMULATED GEN	0 TO 1.0 INCHES
S	STORAGE REQUIREMENTS	-10.6 TO 0 INCHES
W	WATER EQUIV OF PACK	0 TO 30.0 INCHES




AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL

Subalpine Water Balance Simulation Model

Operator's Guide

Preface

(Operator's Guide)

This operator's guide is a complete description of the computer configuration necessary to operate the model. Preparation of the input stream is discussed in detail.

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Effective Use of This Guide

Q. Who should use this guide?

A. It is used by the computer programer, technician, or secretary who is responsible for preparing the user's information for input to a digital computer.

Q. What does the guide contain?

A. It includes:

1. Information about the operating system and the hardware needed to run the job.

2. Examples of system control cards for specific actions:

    a. Binary Program Tape creation
    b. Data tape creation
    c. Permanent file creation
    d. Normal runs

3. Input stream rules and regulations

Q. When should this guide be used?

A. It is used each time changes are made to the input stream (including system control cards).

Q. What preparation is required?

A. The user should have supplied worksheets. (Appendixes A and B of the user's guide)

Q. What are the underlying purposes of this guide?

A. It is intended to provide an overview of the computer configuration and specific step-by-step instructions in the preparation and assimilation of a card deck or input stream. It does not provide "Computer Operator" information, but only "Model Operator" information.

General Information

I. Introduction

The model utilizes pertinent hydrologic and environmental characteristics of a subalpine drainage basin to simulate the water balance. The user may select one or a combination of watershed management practices which include patch-cutting, selection cutting (thinning), or weather modification, and view the hydrologic changes produced by those practices. The effect on water yield is of primary interest; however, changes in other hydrologic components such as: (a) snowpack duration and timing of melt; (b) soil mantle storage depletion/saturation; (c) evapotranspiration; (d) effects in "low" or "high" precipitation years, etc. (A more detailed introduction to the model is included in the User's Guide.)

II. Software Environment

A. Operating system - The model runs under the monitoring of Control Data Corporation's SCOPE 3.3 operating system. All operations follow standard procedures. The following reference manuals are pertinent:

1. Control Data 6000 Computer Series SCOPE Reference Manual 6000 Version 3.3. Publication No. 60305200.

2. Control Data 6400/6500/6600 Computer Systems FORTRAN Extended Reference Manual. Publication No. 60176600.

3. Colorado State University Computer Center Users Manual.

B. Subalpine Water Balance Simulation Model

The individual routines which comprise the model are listed in the inter-routine cross references supplied with the program listing. The FORTRAN source decks are stored at the Rocky Mountain Station Headquarters. The relocatable binary records are stored in mag tape A-244 in the CSU tape library and on mag tape WBMODEL in the Rocky Mountain Station tape library. The routines are in OVERLAY form so the entire package is run each time; the model selects the proper overlay according to the options specified.

III. Hardware Requirements

A. Operating system

The Colorado State University Control Data 6400 Computer System currently consists of the following hardware items:

1 - 6415 CENTRAL PROCESSOR WITH 32K AND 10 PERIPHERAL PROCESSORS
WITH 4K FACIL

10112 6415 MEMORY INCREMENT OF 32K FOR A TOTAL OF 64K

1 - 6603 DISK SYSTEM (DISK FILE AND CONTROLLER) PLUS
10098 6603 DISK SPEED-UP MODIFICATION 1 PLUS
10124 6603 DISK SPEED-UP MODIFICATION 2

1 - 6612 DISPLAY CONSOLE AND CONTROLLER

2 - 3229 MAGNETIC TAPE CONTROLLER
5 - 607 MAGNETIC TAPE TRANSPORTS

2 - 3256 LINE PRINTER CONTROLLERS
2 - 501 LINE PRINTERS

1 - 3447 CARD READER CONTROLLER
1 - 405 CARD READER

1 - 3446 CARD PUNCH CONTROLLER
1 - 415 CARD PUNCH

1 - 3898 MICROFILM RECORDER AND CONTROLLER
1 - 284 MICROFILM RECORDER CABINET

5 - 6681 DATA CHANNEL CONVERTERS
1 - 6671 DATA SET CONTROLLER

3 - 841 DISK PACK UNITS
1 - 3553 CONTROLLER FOR 841

B. Model requirements - The model requires the following items of hardware (and their appropriate controllers):

1. Core storage - 29K (70000_8) to load, 25K (60000_8) to execute

2. Disk system for scratch files

3. 1 tape transport

4. Printer

5. Card Reader

Job Preparation

I. Operating System Control Statements

A. Statements common to all methods

1. Leading statement

JØB CARD*

This card contains a prepunched sequence number for job identification. It must contain the RMFRES account number (A), core requirements (CM), time limit in seconds (T) page limit (PR) and, if tapes are used, the maximum number of transports needed (MT). Example:

TE900,A2CSB1PB,CM70000,T120,PR150,MT1.

2. Trailing statements

```
ØLAYS.                      Execute from the overlay file.
RFL(10000)                  Free all core except that needed for
                            monitor copying.
REWIND(PLØTS)               Ready the plots scratch file and copy to
CØPYCF(PLØTS,ØUTPUT)        the printer.
CØMMENT.NØRMAL TERMINATIØN  Indicate normal termination of processing.
EXIT.                       Stop any abnormal termination and copy
RFL(10000)                  the plots file to the printer. Then
REWIND(PLØTS)               indicate the abnormal termination.
CØPYCF(PLØTS,ØUTPUT)
CØMMENT.ABNØRMAL TERMINATIØN
```

* Ø - represents the letter O. Without the slash, O represents the digit zero.

B. Source deck compilation and execution (data on cards)

JØB CARD	*Request CM70000, T150 + estimated execution time, PR150 + estimated execution output. See part A, 1.*
RFL(50000)	*The full 70000 is not needed for compilation.*
FTN(ØPT=2,RØUND=+-*/,R=0)	*Compiles in optimum mode, causes internal rounding for faster execution (no loss of user accuracy), and lists only the source statements. Other options of R (and L) may be used with appropriate changes in the page limit on the job card.*
RFL(100)	*Courtesy reduction if 70000 not immediately available.*
RFL(70000)	*Get back up to full core.*
MAP(ØFF)	*Eliminate the loader map. (If it is wanted, delete this statement and add 40 to the page limit on the job card).*
LØAD(LGØ)	*Create the overlay file, but do not execute yet.*
NØGØ.	
RFL(60000)	*Free the core needed for loading.*
ØLAYS.	*See comments in part A,2.*
RFL(10000)	
REWIND(PLØTS)	
CØPYCF(PLØTS,ØUTPUT)	
CØMMENT.NØRMAL TERMINATIØN	
EXIT.	

```
RFL(10000)
REWIND(PLØTS)
CØPYCF(PLØTS,ØUTPUT)
CØMMENT.ABNØRMAL TERMINATIØN
```

C. Creation of a relocatable binary program tape and BCD data tape

1. Using 1 reel for multi-file storage

```
JØB CARD                    Request CM70000, T150 + estimated execution
                            time, PR150 + estimated execution output,
                            tape transport MT1.
                            See part A,1.
RFL(50000)                  See part B for additional comments.
FTN(ØPT=2,RØUND=+-*/,R=0)
RFL(100)
RFL(70000)
MAP(ØFF)
LØAD(LGØ)
NØGØ
RFL(60000)
ØLAYS.
RFL(100)                    Courtesy reduction while requesting a tape.
REQUEST,WBMØDEL,MT,ID-__ ,The tape ID and owner's name must be completed.
  WRITE._______(owner)
RFL(10000)                  Get enough core to perform the copying.
REWIND(WBMØDEL,LGØ,TAPE1,   Ready all scratch files and the tape.
  PLØTS)
CØPYBF(LGØ,WBMØDEL)         Copy the relocatable binary program file.
```

```
COPYCF(TAPE1,WBMØDEL)
REWIND(WBMØDEL)
CØPYCF(PLØTS,ØUTPUT)
CØMMENT.NØRMAL TERMINATIØN
EXIT.
RFL(10000)
REWIND(PLØTS)
CØPYCF(PLØTS,ØUTPUT)
CØMMENT.ABNØRMAL TERMINATIØN
```

Copy the BCD data file.

Cause the "End of Information" to be written on the tape.

2. Using 2 separate reels

```
JØB CARD
RFL(50000)
FTN(ØPT=2,RØUND=+-*/,R=0)
RFL(100)
RFL(70000)
MAP(ØFF)
LØAD(LGØ)
NØGØ.
RFL(60000)
ØLAYS.
RFL(100)
REQUEST,WBMØDEL,MT,ID-__,
  WRITE._____(owner)
```

Request CM70000,T150 + estimated execution time, PR150 + estimated execution output, tape transport MT2. See part A,1.

See part B for additional comments

Courtesy reduction while requesting tapes.

The ID and owner's name must be completed.

```
REQUEST,DATAFIL,MT,ID-__,
  WRITE._______(owner)

RFL(10000)                    Get enough core to perform the copying

REWIND(WBMØDEL,DATAFIL,LGØ,   Ready all scratch files and the tapes.
  TAPE1,PLØTS)

CØPYBF(LGØ,WBMØDEL)           Copy the binary program file.

CØPYCF(TAPE1,DATAFIL)         Copy the BCD data file.

REWIND(WBMØDEL,DATAFIL)       Cause the "End of Information" to be written
                                on the tapes.
CØPYCF(PLØTS,ØUTPUT)

CØMMENT.NØRMAL TERMINATIØN.

EXIT.

RFL(10000)

REWIND(PLØTS)

CØPYCF(PLØTS,ØUTPUT)

CØMMENT.ABNØRMAL TERMINATIØN.
```

D. Execution from relocatable binary program tape

1. Data on cards

```
JØB CARD                      Request CM70000, T30 + estimated execution
                              time, PR2 + estimated execution output,
                              tape transport MT1.  See part A,1.

RFL(100)                      Courtesy reduction while requesting tape.

REQUEST,WBMØDEL,MT,ID-__,     The ID must be completed.
  READ.

RFL(70000)                    Get back up to full core.

MAP(ØFF)                      Eliminate the loader map.
```

```
REWIND(WBMØDEL)          Ready the tape, create the overlay file, but
LØAD(WBMØDEL)            do not execute yet.
NØGØ.
RETURN(WBMØDEL)          Release the tape transport.
RFL(60000)               See Part B for additional comments
ØLAYS.
RFL(10000)
REWIND(PLØTS)
CØPYCF(PLØTS,ØUTPUT)
CØMMENT.NØRMAL TERMINATIØN
EXIT.
RFL(10000)
REWIND(PLØTS)
CØPYCF(PLØTS,ØUTPUT)
CØMMENT.ABNØRMAL TERMINATIØN
```

2. Data on multi-file reel

```
JØB CARD                 Request CM70000,T15 + estimated execution
                         time, PR2 + estimated execution output,
                         tape transport MT1.  See part A,1.
RFL(100)                 See part D,1 for additional comments
REQUEST,WBMØDEL,MT,ID-__,
  READ.
RFL(70000)
MAP(ØFF)
LØAD(WBMØDEL)
NØGØ.
```

```
CØPYCF(WBMØDEL,TAPE1)        Copy the data file.
RETURN(WBMØDEL)
RFL(60000)                   See part B for additional comments.
ØLAYS.
RFL(10000)
REWIND(PLØTS)
CØPYCF(PLØTS,ØUTPUT)
CØMMENT.NØRMAL TERMINATIØN
EXIT.
RFL(10000)
REWIND(PLØTS)
CØPYCF(PLØTS,ØUTPUT)
CØMMENT.ABNØRMAL TERMINATIØN
```

3. Data on separate reel

```
JØB CARD                     Request CM70000,T15 + estimated execution
                             time, PR2 + estimated execution output,
                             tape transport MT1.
RFL(100)                     See part D,1 for additional comments.
REQUEST,WBMØDEL,MT,ID-__,
  READ.
RFL(70000)
MAP(ØFF)
```

```
REWIND(WBMØDEL)
LØAD(WBMØDEL)
NØGØ.
UNLØAD(WBMØDEL)          Release this reel but retain the transport.
RFL(100)                 Courtesy reduction
REQUEST,TAPE1,MT,ID-__,  Get the data tape (the ID must be completed)
  READ.                  by the name TAPE1 (rather than DATAFIL) so
                         it can be used directly.
RFL(60000)               Get back up to the core needed for execution.
                         See part B for additional comments.
ØLAYS.
RFL(10000)
REWIND(PLØTS)
CØPYCF(PLØTS,ØUTPUT)
CØMMENT.NØRMAL TERMINATIØN
EXIT.
RFL(10000)
REWIND(PLØTS)
CØPYCF(PLØTS,ØUTPUT)
CØMMENT.ABNØRMAL TERMINATIØN
```

E. Creation of a permanent file (The statements below operate on a multi-file reel--see part D,2. Appropriate changes in the other statements sections could be used to create the permanent file.)

```
JØB CARD                          Request CM70000, T15 + estimated execution
                                  time, PR2 + estimated execution output,
                                  tape transport MT1.  See part A,1.
RFL(100)                          See part D,2 for additional comments
REQUEST,WBMØDEL,MT,ID-__,
  READ.
RFL(70000)
MAP(ØFF)
REWIND(WBMØDEL)
REQUEST,ØLAYS,*PF.                Specify that the overlay and scratch files
                                  must be on permanent file devices.
REQUEST,TAPE1,*PF.
LØAD(WBMØDEL)
NØGØ.
CØPYCF(WBMØDEL,TAPE1)
RETURN(WBMØDEL)
RFL(60000)
ØLAYS.
RFL(10000)
REWIND(PLØTS)
CØPYCF(PLØTS,ØUTPUT)
REWIND,ØLAYS,TAPE1.
CATALØG(ØLAYS,WATERBALANCEMØDEL,  Make the files permanent; the password
  CY=1,CN=_____,RP=_____,         (Control Name), Retention Period (number of
  ID=_____)                       days) and ID must be completed.  Note the
                                  = with the ID, not a -.
CATALØG(TAPE1,WATERBALANCEMØDEL,
  CY=2,CN=_____,RP=_____,
  ID=_____)
```

```
COMMENT.NORMAL TERMINATION
EXIT.
RFL(10000)
REWIND(PLOTS)
COPYCF(PLOTS,OUTPUT)
COMMENT.ABNORMAL TERMINATION
```

After successful cataloging, obtain the Sub Directory number from the day file for use with the ATTACH statements.

F. Execution from a permanent file.

```
JOB CARD
ATTACH(OLAYS,WATERBALANCEMODEL,
  CY=1,ID=_____,SD=_____)
ATTACH(TAPE1,WATERBALANCEMODEL,
  CY=2,ID=_____,SD=_____)
OLAYS.
RFL(10000)
REWIND(PLOTS)
COPYCF(PLOTS,OUTPUT)
COMMENT.NORMAL TERMINATION
EXIT.
RFL(10000)
REWIND(PLOTS)
COPYCF(PLOTS,OUTPUT)
COMMENT.ABNORMAL TERMINATION
```

Request CM60000, T = estimated execution time, PR2 + estimated execution output. See part A,1.

Ready the permanent files. The ID must be the same as that when cataloging took place, the Sub Directory is optional, but helpful. It is found in the DAYFILE of the cataloging run.

G. Purging a permanent file

```
JØB CARD                              Request CM10000.  See part A,1.

ATTACH(ØLAYS,WATERBALANCEMØDEL,       Ready the permanent files as above.
  CY=1,PW=_____,ID=_____,
  SD=_____)                           The Password must be the same as the

ATTACH(ØLAYS,WATERBALANCEMØDEL,       Control Name used in cataloging
  CY=2,PW=_____,ID=_____,
  SD=_____)

PURGE(ØLAYS)                          Perform the purge.

PURGE(TAPE1)
```

II. FORTRAN source statments: When the user is operating from the source statements (implying a compilation) this deck of approximately 10,000 cards must be provided. The deck is sequenced by routines (columns 73-75) and by card number within routines (columns 77-79). Column 80 is normally blank, but may contain numeric and alphabetic characters for ordering alterations to the deck. (Sequence is A-Z, 0-9.)

III. Model Parameters: This deck of cards is mandatory for all runs, regardless of whether the data (climatological observations) is on cards or tape. It is prepared by the operator from the user completed sheets found in the appendices in the User's Guide. It contains the selected options and the parameters necessary for execution. The order and format of each card is discussed below.

A. SELECT - This card specifies the options the user is selecting for the run.

Card Col	Contents and Format
1-6	SELECT
8	Input file (5=cards, 1-model edited tape)(*I1*)
10	Output option (See col. 12-13 and 17)(*I1*)
12-13	Date-divisible-by (used with Interval Sums output)(*I2*)
17	Output sub-option (used with individual stations (*I1*)
20	Alternative (*I1*)
22-23	Patch-cut percent (*F2.2*)
25-56	Precip. increase (%) due to cloud seeding (*F2.2*)
28-29	Thinning percent (*F2.2*)
31-34	Month and day cloud seeding starts
36-39	" " " " " ends
41-65	Station Indicator (Used to indicate stations subjected to timber harvesting or stations for individual station output)(*25I1*)

B. PLØTS - This card indicates how the plotting (graphing) is to be handled.

Card Col	Contents and Format	
1-5	PLØTS	
10	Normal Simulation Hydrograph	(*I1*)
12	" " W.E.	(*I1*)
14	" " Input	(*I1*)
16	" " ET	(*I1*)
18	" " Storage	(*I1*)
20	" " Runoff	(*I1*)
22	Alternative W.E.	(*I1*)
24	" Input	(*I1*)
26	" ET	(*I1*)
28	" Storage	(*I1*)
30	" Runoff	(*I1*)
31-35	Maximum Value, Hydrograph	(*F5.2*)
36-40	" " W.E.	(*F5.2*)
41-45	" " Input	(*F5.2*)
46-50	" " ET	(*F5.2*)
51-55	" " Storage	(*F5.2*)
56-60	" " Runoff	(*F5.2*)

C. Watershed Identification

Col	Contents and Format	
1-60	Watershed Name and/or Description	(*6A10*)
71-74	Summer Precip adjustment %	(*F4.2*)
76-77	Number of Stations	(*I2*)
79-80	Number of Years	(*I2*)

D. Daily Potential Radiation

Col	Contents and Format	
1-13	PØTENTIAL RAD	
16-20	Pot. Rad. on 6/22	(*F5.0*)
21-25	7/12	(*F5.0*)
26-30	7/27	(*F5.0*)
31-35	8/10	"
36-40	8/25	"
41-45	9/9	"
46-50	9/23	"
51-55	10/8	"
56-60	10/22	"
61-65	11/5	"
66-70	11/19	"
71-75	12/3	"
76-80	12/22	"

E. Substation Cards - 1 set per station (The number of sets must be the same as specified in columns 76-77 of the Watershed ID Card--see part C)

1. Substation Identification

Col	Contents and Format	
1-50	Substation name and/or description	(*5A10*)
51-60	Substation code	(*A10*)
61-65	Area Weight %	(*F5.2*)

2. SUBSTATION CONSTANTS

Col	Contents and Format	
1-20	SUBSTATION CONSTANTS	
21-25	Transmissivity Coeff, %	(*F5.2*)
26-30	Cover density, %	"
31-35	Maximum Cover density, %	"
40	Vegetation Type	(*I1*)
41-45	Reflectivity Threshold, °F	(*F5.0*)
46-50	Melt Threshold, °F	(*F5.0*)
51-55	Wilting Point,-in.	(*F5.2*)
56-60	Deciduous Winter Trans Coeff, %	(*F5.2*)
61-65	" " Cov Den, %	(*F5.2*)
66-70	" " Max Cov Den, %	(*F5.2*)

3. INITIAL CONDITIONS

Col	Contents and Format	
1-18	INITIAL CONDITIONS	
21-25	Normal Sim Pack Temp, °C	(*F5.2*)
26-30	" " Pack W.E., in.	(*F5.2*)
31-35	" " Recharge req.,-in.	(*F5.2*)
40	" " Blank or 1 (1=Ready to control snowpack temp)	(*I1*)
41-45	Area 1 Pack Temp, °C	(*F5.2*)
46-50	" " Pack W.E., in.	"
51-55	" " Recharge Req.,-in.	"
60	" " Blank or 1	(*I1*)
61-65	Area 2 Pack Temp, °C	(*F5.2*)
66-70	" " Pack W.E., in.	"
71-75	" " Recharge Req.,-in.	"
80	Blank or 1	(*I1*)

4. DAILY ET

Col	Contents and Format	
1-8	DAILY ET (inches)	
21-25	Average daily ET, Jan	(*F5.4*)
26-30	" " " Feb	"
31-35	" " " Mar	"
36-40	" " " Apr	"
41-45	" " " May	"
46-50	" " " June	"

51-55	Average daily ET, July	(*F5.4*)
56-60	" " " Aug	"
61-65	" " " Sept	"
66-70	" " " Oct	"
71-75	" " " Nov	"
76-80	" " " Dec	"

5. Air Temperature Coefficients

Col	Contents and Format	
1-14	AIR TEMP CØEFF	
21-25	$A_{Maximum}$	(*F5.3*)
26-30	$B_{Maximum}$	(*F5.3*)
31-35	$A_{Minimum}$	(*F5.3*)
36-40	$B_{Minimum}$	(*F5.3*)

6. Slope/Aspect Adjustment Factors

Col	Contents and Format		
1-12	SLØPE/ASPECT		
16-20	Factor for	6/22	(*F5.2*)
21-25		7/12	"
26-30		7/27	"
31-35		8/10	"
36-40		8/25	"
41-45		9/9	"
46-50		9/23	"
51-55		10/8	"
56-60		10/22	"
61-65		11/5	"

66-70	Factor for 11/19	(*F5.2*)
71-75	12/3	12/3 "
76-80	12/22	12/22 "

7. SPECIFIED CØNDITIØNS - Each substation set must contain 1 card for each year (number of cards specified in col 79-80 of the watershed ID card--see section C.)

Col	Contents and Format	
1-19	SPECIFIED CØNDITIØNS	
21-25	Peak W.E., in.	(*F5.2*)
26-30	Accumulated Case station precip on date of peak W.E.	(*F5.2*)
32-37	Date of Peak W.E.	(*I6*)
39-44	Isothermal date	(*I6*)

IV. Data (Climatological Observations)--When the user's data has not been edited and written on tape by the model, cards must be supplied for the run. There should be one card per day which contains the date, the maximum and minimum temperatures (°F), and the precipitation (in.). The observed generated runoff (area in.) may also be included. These items may be in any order and format on the card as the user specifies both order and format for the deck.

Figure 1

ORGANIZATION OF MODEL PARAMETERS DECK

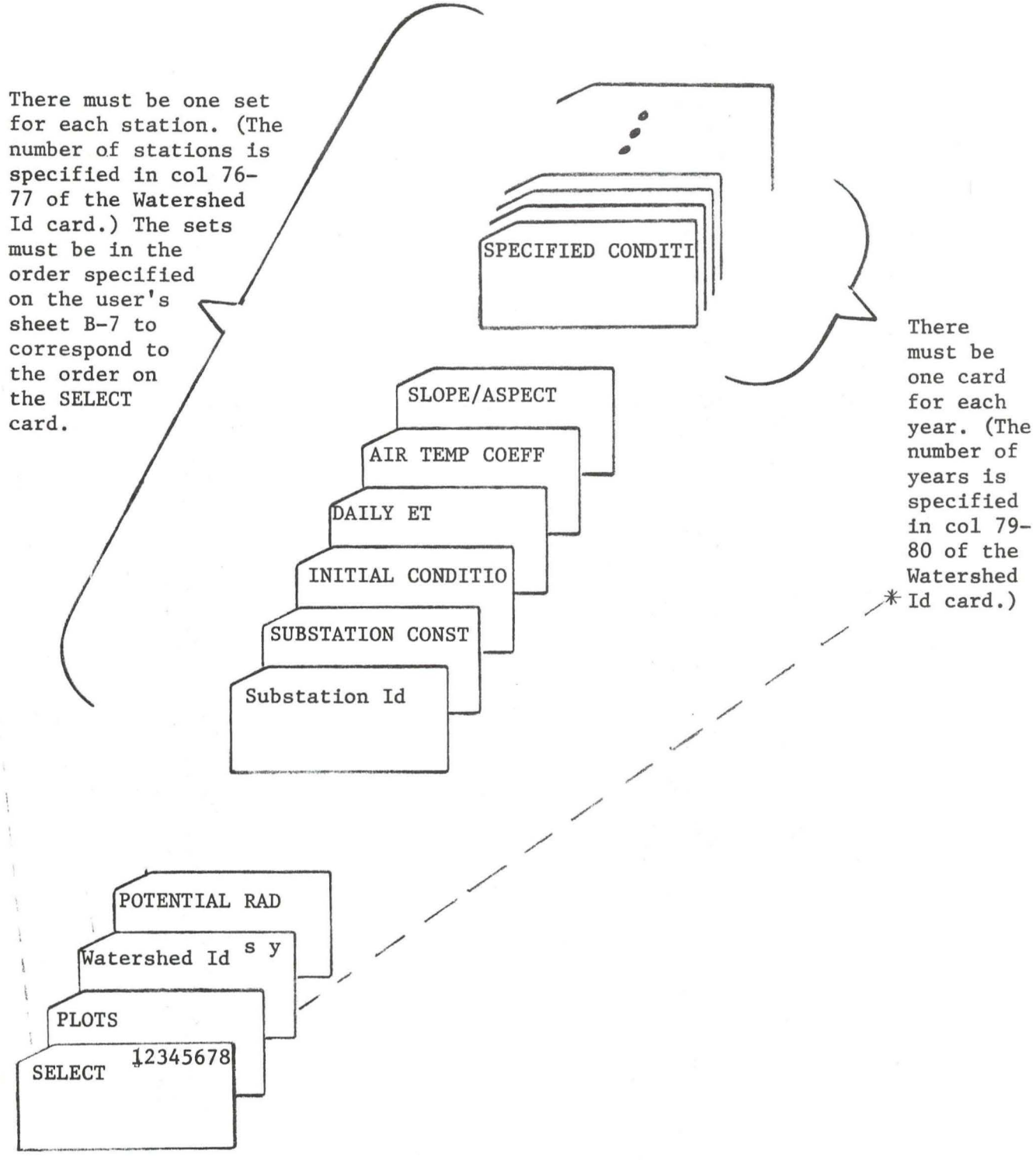
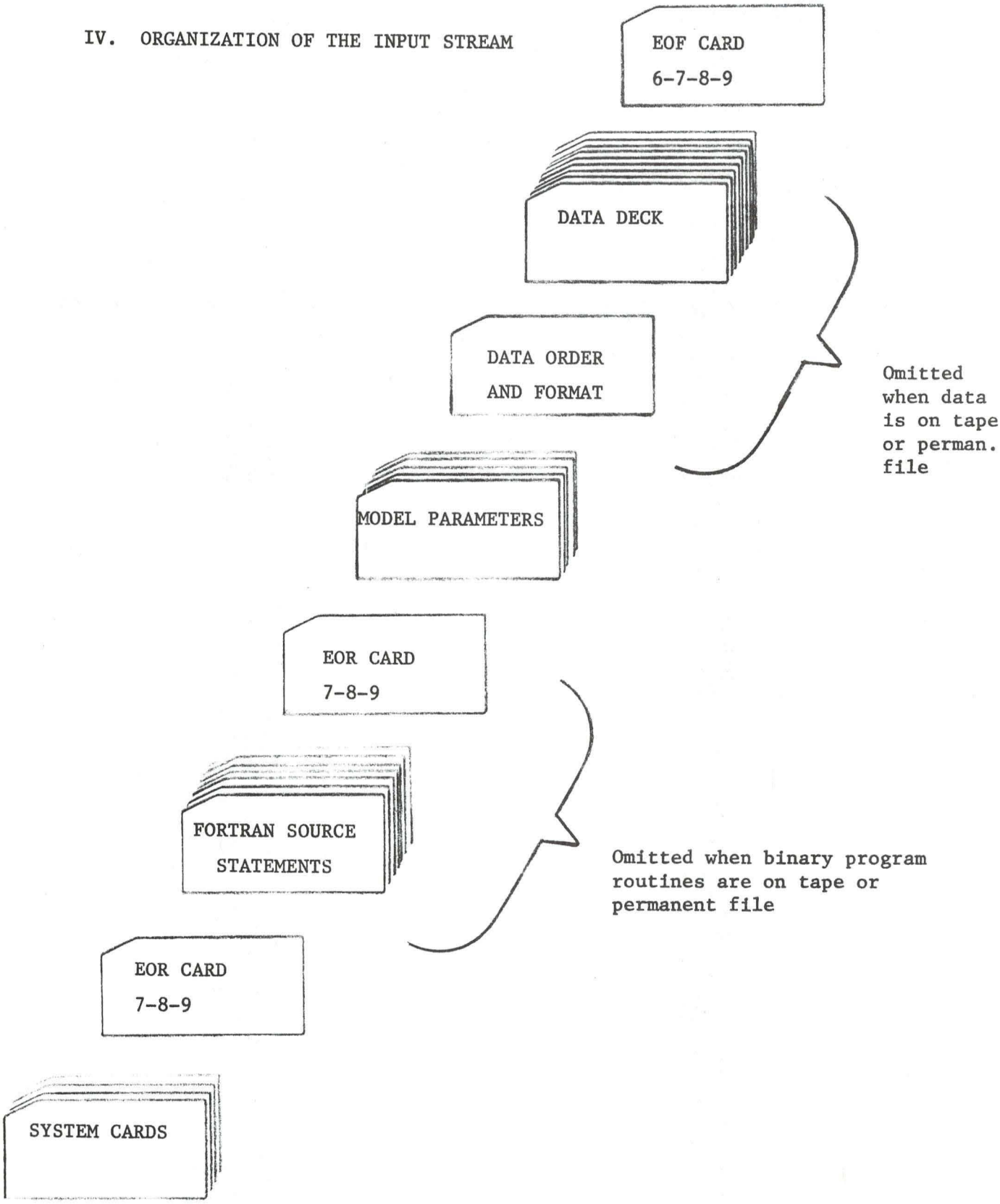

There must be one set for each station. (The number of stations is specified in col 76-77 of the Watershed Id card.) The sets must be in the order specified on the user's sheet B-7 to correspond to the order on the SELECT card.
SPECIFIED CONDITI
SLOPE/ASPECT
AIR TEMP COEFF
DAILY ET
INITIAL CONDITIO
SUBSTATION CONST
Substation Id
There must be one card for each year. (The number of years is specified in col 79-80 of the Watershed Id card.)
POTENTIAL RAD
Watershed Id s y
PLOTS
SELECT 12345678

Figure 2

IV. ORGANIZATION OF THE INPUT STREAM



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SUBALPINE WATER BALANCE SIMULATION MODEL

DOCUMENTATION

Storage Routing

Storage Routing

The method of routing water available for streamflow (generated runoff) is based on the law of continuity in the storage equation:

$$S_1 + I - \left(\frac{Q_1 + Q_2}{2}\right) = S_2 \qquad [1]$$

where

S_1 = storage on the watershed at the beginning of a time interval (1 day),
I = input (generated runoff) during the interval,
Q_1 = outflow at the beginning of an interval,
Q_2 = outflow at the end of the interval, and
S_2 = storage at the end of the interval.

All of the variables in equation [1] are in inches.

In performing the routing computation, the computer obtains simultaneous solutions for equation [1] and the basin storage-discharge relationship. An index of storage is obtained from a volume-versus-flow curve developed for a given watershed which relates discharge to the remaining runoff volume beneath the average recession curve. Figure 1 is an example of a curve developed for a subalpine watershed in the Fraser Experimental Forest.

Storage on a watershed is expressed by the equation:

$$Q = a + b_1 S + b_2 S^2 + b_3 S^3 + \ldots . \qquad [2]$$

Rewriting [1],

$$(S_1 - \frac{Q_1}{2}) + I = (S_2 + \frac{Q_2}{2}) \qquad [3]$$

and combining equations [2] and [3] results in the expression:

$$(S - \frac{Q_1}{2}) + I = S_2 + \frac{1}{2}(a + b_1 S_2^2 + b_3 S_2^2 + \ldots) \qquad [4]$$

from which S_2 can be determined, given the initial conditions S_1 and Q_1 and the input during the interval. Substitution of S_2 into equation [3] yields the discharge at the end of the interval, Q_2. Figure 2 is a simplified flow chart of the computational procedure.

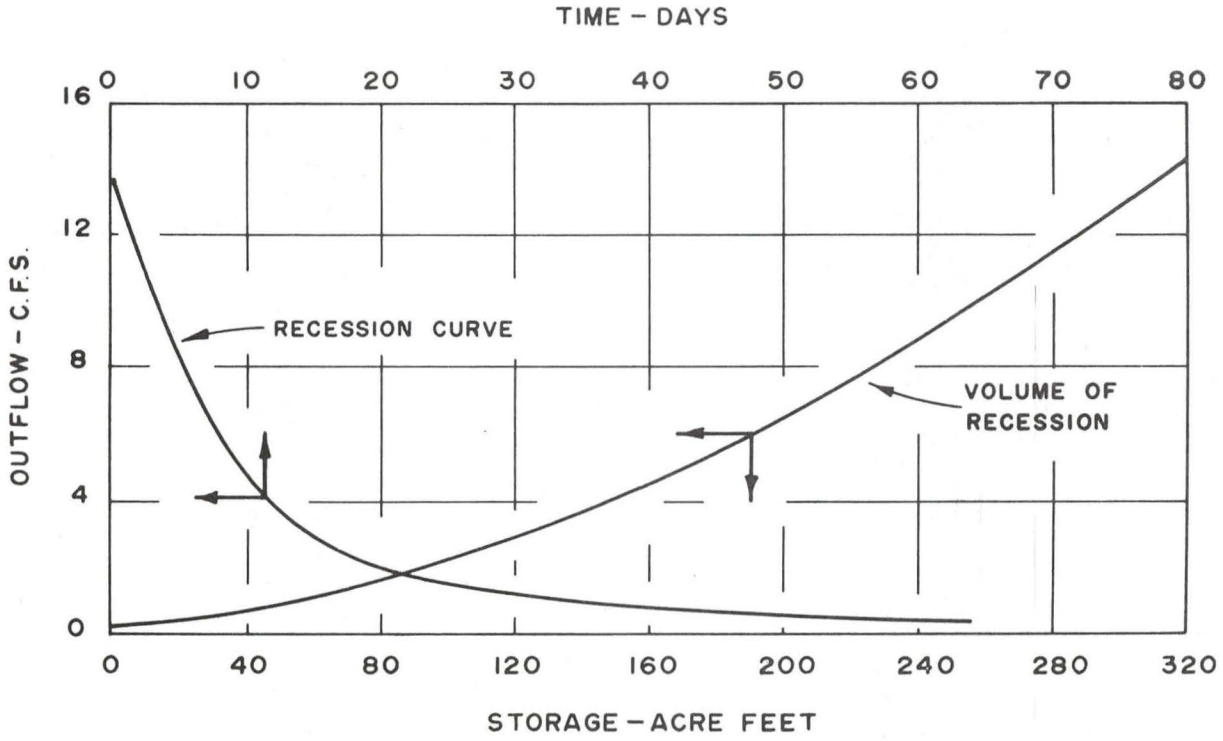

Figure 1.--Recession and outflow-storage curves for subalpine watershed.

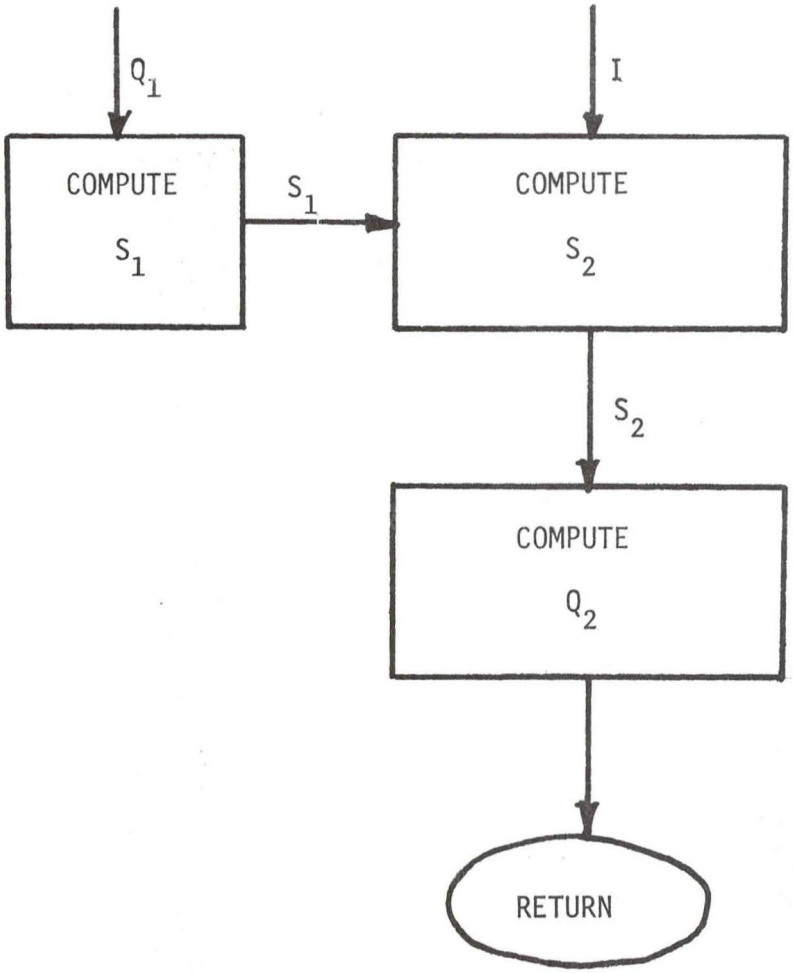

Figure 2.--Simplified storage routing procedure.